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ORIGINAL ARTICLES.

I.—Prof. E. D. Cope, on a New Type of Perissodactyle Ungulate from the Wasatch Eocene of Wyoming Territory, United States of North America.

(PLATE II.)

In his last published volume on the Vertebrata of the Territories,[1] Prof. Edward D. Cope has figured and described many new and remarkable forms of the Order Ungulata from the Eocene of Wyoming. The most important and interesting among the numerous species described being the genus *Phenacodus*, of which the nearly entire skeletons of two species have been discovered, namely *P. primævus*, represented in our plate (Plate II.) and *P. Vortmani*. So far as the present evidence goes, *Phenacodus* appears to have been the *most generalized form* of a Perissodactyle Ungulate hitherto described, though other contemporary genera may ultimately show characters as generalized, when the relation of those species founded upon the dentition to those founded on the detached bones of the extremities is better known. The teeth of *Phenacodus* are tuberculated, with intervening valleys, resembling the dentition of some of the bunodont Artiodactyla, whilst the femur has a third trochanter, and the fore and hind feet have each five well-developed digits, showing it to be a Perissodactyle or odd-toed ungulate.

Again, the scapula is widened anteriorly, as in the Ursine Carnivora, the Amblypoda and Proboscidea. With the last group the form of the ulna also coincides, being large and broad relatively to the radius, and also in that the bones of the carpus do not interlock.

From these coincidences of structure Prof. Cope says, "This genus must be placed in a special group of an order which includes the Proboscidea" (p. 383). On the other hand, in a lecture on the Horse, recently delivered at the City of London Institute, Prof. W. H. Flower, LL.D., F.R.S., infers, from certain structural characters, that it was an early ancestor of the *Equidæ*. However, the following general description of the genus (extracted chiefly from the "American Naturalist,"[2] and reproduced again in Prof. E. D. Cope's later and grander work) will better serve to convey, in the author's own

[1] "Report United States Geological Survey of the Territories," F. V. Hayden. vol. iii. "The Vertebrata of the Tertiary Formation of the West," Edward D. Cope. Washington, 1884 (inner title 1883); 4to. pp. xxxiv. and 1009; plates 75, several folding.

[2] The American Naturalist, vol. xv. 1881, p. 1017.

words, the leading facts in reference to this remarkable Eocene Mammal.

"A New Type of Perissodactyle Ungulate.

In a paper on the 'Homologies and Origin of the Molar Teeth of the Mammalia Educabilia,' published in March, 1874, I ventured the generalization that the primitive types of the Ungulata would be discovered to be characterized by the possession of five-toed plantigrade feet, and tubercular teeth. No Perissodactyle or Artiodactyle mammal was known at that time to possess such feet, nor was any Perissodactyle known to possess tubercular teeth. Shortly after advancing the above hypothesis, I discovered the foot structure of *Coryphodon*, which is five-toed and plantigrade, but the teeth are not of the tubercular type. For this and allied genera, I defined a new order, the Amblypoda, and I have published the confident anticipation that genera would be discovered which should possess tubercular (bunodont) teeth. This prediction has not yet been realized. I now, however, record a discovery, which goes far towards satisfying the generalization first mentioned, and indicates that the realization of the prophecy respecting the Amblypoda is only a question of time.

In 1873 I described, from teeth alone, a genus under the name of *Phenacodus*, and although a good many specimens of the dentition have come into my possession since that date, I have never been able to assign the genus its true position in the mammalian class. The teeth resemble those of suilline Ungulates, but I have never had sufficient evidence to permit its reference to that group. Allied genera recently discovered by me have been stated to have a hog-like dentition, but that their position could not be determined until the structure of the feet shall have been ascertained.

In his recent explorations in the Wasatch Eocene of Wyoming, Mr. J. L. Wortman was fortunate enough to discover a nearly entire skeleton of a *Phenacodus* very near the typical *P. primævus*, which presents all the characters essential to a full determination of its place in the system. The unexpected result is, that this genus must be referred to the order Perissodactyla and the Proboscidea, and that, with its allies, it must form a special division of that order corresponding in the tubercular characters of its teeth with the bunodont or suilline division of the Artiodactyla. In this character, however, there is a closer gradation than in the case of the Artiodactyla, and it would scarcely be necessary to create such a group on that character alone. But the genus differs further from the Perissodactyla and approaches the Proboscidea, in the fact that the astragalus articulates with the navicular only, and by a universally convex surface, as in the Carnivora.

The astragalus resembles that of the latter order very closely, and differs from that of *Hyracotherium* and the nearest forms among the Perissodactyla. *Phenacodus* has, moreover, five well-developed toes on all the feet, and was probably not entirely plantigrade. The cast of the brain-case shows that the cerebral hemispheres were quite small and nearly smooth, and that the very large cerebellum and

olfactory lobes were entirely uncovered by them. The bones of the two carpal rows alternate with each other, and there is a third trochanter on the femur. The cervical vertebræ are opisthocœlous. The systematic position of the genus may be schematically represented as follows:

Order PERISSODACTYLA. Ungulate; digits of unequal lengths; carpal bones alternating; a postglenoid process. Astragalus with proximal trochlea, and without distal double ginglymus.

Suborder *Diplarthra.* Astragalus distally plane or concave in one direction, and uniting with both navicular and cuboid bones; a third trochanter on the femur. The known families belonging here.

Suborder *Condylarthra.* Astragalus convex in all directions distally; only uniting with navicular bone; a third trochanter on the femur.

Family *Phenacodontidæ.* Molar teeth tubercular; the premolar teeth different from the molars; five digits on all the feet.

Genera: *Phenacodus,* Cope, and very probably *Catathlæus,*[1] *Mioclænus,* and *Protogonia,*[2] Cope; and perhaps also *Anisonchas,* Cope. These genera include fifteen species, all from the Lower Eocene beds. The Condylarthra are then the ancestral type of the known Perissodactyla, that is, of the Horses, Tapirs, and Rhinoceroses, and of the numerous extinct forms."

Prof. Cope arrives at the following conclusions as to the measurements of the entire animal as figured (see Plate II.). "The measurements of *Phenacodus primævus* show that this species was as large as a 'Big-horn';[3] that its body was rather longer than in that animal, and its legs shorter and more robust. It was in fact proportioned more as in the common American Tapir, but was of smaller size. The middle three toes of both feet reached the ground, whilst the first and fifth projected laterally and posteriorly, like the dew-claws of the Hogs. The tail was longer and heavier than that of any of the living hoofed mammals, resembling in its proportions that of the Wolf. The eyes were small and the muzzle long, but was singularly soft above and near the extremity. Whether this soft part was pierced by valvular muscles, as in the Hippopotamus, or was produced into a short proboscis, as in the Saiga (Antelope) or in the Tapir, cannot be certainly ascertained, but there are indications of the insertion of important cartilages, if not muscles, on the superior faces of the premaxillary bones.

The animal was probably omnivorous in its diet. It was not furnished with any weapons of offence or defence pertaining to the osseous system, so that it must have sought refuge in flight. The well-developed muscular insertion of its limbs, and the digitigrade character of its step, indicate that it may have had considerable speed."

"*Distribution.*—The bones of this species have been found wherever the beds of the Wasatch Epoch occur, but most abundantly in

[1] American Naturalist, October, 1880.
[2] Proceedings American Philosophical Society, September, 1881.
[3] *Ovis Canadensis,* "The Rocky Mountain Sheep."

Northern Wyoming. From the Wind River Valley Mr. Wortman brought two specimens, and ten from the Big-Horn Basin." (*op. cit.* pp. 462–463).

NOTE.—We are indebted to the kindness of Prof. E. D. Cope for permission to reproduce the figure of *Phenacodus* given in our Pl. II. —EDIT. GEOL. MAG.

II.—AN ANSWER TO "OBSERVATIONS ON SOME IMPERFECTLY KNOWN MADREPORARIA FROM THE CRETACEOUS FORMATION OF ENGLAND, BY R. F. TOMES, ESQ., F.G.S."

By Prof. P. MARTIN DUNCAN, F.R.S.

I HEARD this communication read at the Geological Society in June last, and I made some remarks upon it which are noticed in the Proceedings of the Society. A considerable portion of the paper consisted of criticisms of some of my work which appeared in the British Fossil Corals (2 ser. Pal. Soc. part ii. Nos. 1 and 2, 1869–70). Some specimens were exhibited, in the author's absence, which were presumed to afford evidence of a satisfactory kind. But it was observed that the very imperfect and bad condition of the fossils did not substantiate the author's statements. Many specimens which ought to have been exhibited were not before the Society, and yet the classificatory position of some very rare corals could then and there have been settled. As this paper was not published by the Geological Society, as the author ignores the remarks I made on the paper, and as it appears in the GEOLOGICAL MAGAZINE for December, 1885, p. 541, I ask a small space for a reply.

In answer to Mr. Tomes, I assert that *Micrabacia Fittoni*, nobis (Pal. Soc. *loc. cit.* p. 37, pl. xiv. figs. 6, 7, 8, 9), is not a variety of *Cyclocyathus Fittoni*, Edw. and Haime (Pal. Soc. Brit. Foss. Corals, pt. i. p. 63, pl. xi. figs. 3, 3*a*, 3*b*, 1850). Neither is it that species. The species of *M. Fittoni* was founded upon a solitary yet good specimen, and the drawings of it were good and from nature. Some years after the description of the species, I investigated the morphology of *Micrabacia coronula*, and the results were published (Quart. Journ. Geol. Soc. vol. xl. 1884. p. 561).[1] I pointed out that there was reason to doubt whether *M. Fittoni* was a true *Micrabacia;* but that as the type was not accessible, I did not feel disposed to remove the form until I had an opportunity of investigating it anew. It was, however, not necessary to place the form out of the Fungida, to which section it belongs. I should have been glad to have seen another specimen, but Mr. Tomes did not give me the opportunity, and I am aware that he has not the type. So it is now necessary to compare the form I described with the species with which it is attempted to be associated, namely, *Cyclocyathus Fittoni.*

Amongst the structural details of *Cyclocyathus Fittoni*, Edw. and Haime, is a thin epitheca, and the costæ of the first and second cycles are more prominent than the others; these details are not seen in *M. Fittoni.* The upper or calicular surface is rather convex

[1] Omitted be to noted by Mr. Tomes.

externally and concave towards the centre, and the fossa is large and well marked, whilst the columella is fasciculate, broad, and papillose at the surface in *Cyclocyathus;* but in *Micrabacia* the corallum is *hemispherical* and there is no large fossa in the entirely convex calice, and the small columella has no papillæ. There are pali and no synapticulæ in *Cyclocyathus*, and there are no pali and many synapticulæ in *Micrabacia*.

The student of the Madreporaria who will turn to the figures of the types of the two forms in the Pal. Soc. *loc. cit.* will have no difficulty in recognizing their distinctness. *Cyclocyathus* is an aporose coral, and *Micrabacia* is a true Fungid. Mr. de Wilde drew *M. Fittoni*, nobis, from nature.

Smilotrochus insignis, nobis (Pal. Soc. *loc. cit.* p. 37, pl. xiv. fig. 18, 1870). This is stated by Mr. Tomes to be a *Ceratotrochus*. The morphology of *Smilotrochus* and *Ceratotrochus* was considered in my "Revision of the Genera and Families of the Madreporaria" (Linn. Soc. Journ. Zool. 1884), and it is noticed that *Ceratotrochus* is a *Smilotrochoid* with a columella. The columella of this genus is bundle-shaped and broad (fasciculate),[1] and processes arise from the inner edges of the larger septa and ascend into it and add to its bulk. The top of the columella is papillary and high up in the coral. The specimen with a so-called columella I had not the advantage of seeing, but there is a drawing of it in Mr. Tomes's paper (Geol. Mag. 1885, Pl. XIV. Fig. 6), and it is evidently a diagram. What is considered to be the columella is not a fasciculate structure gaining processes from the septa, nor is it a spongy columella, but a mass of matrix which always fills up the lower parts of these corals. The mass occupies the axis, and the rounded top is artificial. *Smilotrochus insignis*, nobis, is not a *Ceratotrochus*, and one of the reasons is that it has no columella.

Smilotrochus granulatus, nob. (*op. cit.* p. 36, pl. xiv. fig. 17). This is said by Mr. Tomes to be an immature *Trochocyathus Wiltshirei*, nobis. I should have been glad to have seen a specimen of the interesting *T. Wiltshirei*, and still more to have seen the proofs that a well-characterized *Smilotrochus* without columella and pali could become a form with those essential characters in the growth of one-tenth of an inch, and also increase from three to four cycles in the same space. The height of the type *T. Wiltshirei*, nob., is three-tenths of a inch, and that of the *Smilotrochus* is two-tenths of an inch. The cyclical arrangement and the nature of the costæ and of the calice distinguish the two forms perfectly. There is no evidence that one form could turn into another, and the species *Smilotrochus granulatus*, nobis, is not the same as *T. Wiltshirei*, nobis, for it has neither columella nor pali.

Podoseris mammiliformis, nobis, and *P. elongata*, nobis (Pal. Soc. *loc. cit.* p. 25, pl. ix. figs. 2–17). These species are stated to be species of *Rhizangia*, Ed. and H. To disprove this it would suffice to draw attention to the above-mentioned figures of the types and to the figures given of *Rhizangia* by Reuss (Denks. d. Wien. Akad. der

[1] Not spongy as Mr. Tomes states.

Wiss. t. vii. p. 120, pl. 7, fig. 7, 8, and fig. 9–11; also M. Ed. and Haime, Ann. des Sci. Nat. 3rd ser. t. x. pl. 7, fig. 7 and 8); but it is as well to call attention to the fact that perfect specimens of *Podoseris* have convex and more or less hemispherical upper surfaces, and that their bases are perforated, whilst there are synapticulæ between the septa. The form is not a social one, and never springs from stolons like *Rhizangia*, which has a wall, a flat upper surface with a shallow calice, and is seated upon a stoloniferous base which may extend beyond and give origin to others.

The figures given by Mr. Tomes (7 and 8) show that there are no stolons present. A stolon is a structure on which the bases of corallites grow, and it is not a growth from the edge of the base of a corallite. In the very numerous specimens of *Podoseris* from the Red Chalk which the Rev. Mr. Wiltshire placed at my disposal there were no traces of stolons. No union by stoloniferous growth existed in the specimens which were exhibited by Mr. Tomes at the Geol. Soc., and although he states that "three corallites are united by the stolon" (p. 552), it does not appear in the illustration (Fig. 7). I especially drew attention to the want of stolons and such union in the remarks I made on Mr. Tomes's paper at the Geological Society, and my remark was published in the Abstract of Proceedings. Nevertheless, Mr. Tomes persists in stating what he cannot substantiate.

I draw attention to Mr. Tomes's Fig. 10, which professes to represent synapticulæ. On Plate XIV. is printed "R. F. Tomes, del.," so that this is not a mistake of the artist. The figure proves that its author has views regarding the nature of synapticulæ which are not those of any other zoophytologist. Synapticulæ pass from one septum to another. In Fig. 9, synapticulæ are called dissepiments. Figure 11 of the Plate is acknowledged to be wrong, and should not have been printed, for it leads to a mistaken view of the structures it purports to represent. *Syzygophyllum*, Reuss, is not in the least like a *Podoseris*, and is synonymous with *Antillia*, nobis, a subgenus of *Circophyllia*; it has no stolons. *Podoseris* is a well-defined natural genus and is one of the Fungidæ, and *Rhizangia* is one of the Aporosa.

Turbinoseris, nobis ("Revision of the Genera," p. 148). This genus is stated by Mr. Tomes to be synonymous with *Leptophyllia*, Reuss. They are distinct for morphological reasons. Pratz in his article (Palæontographica, 1882, p. 90) has shown that the septa of *Leptophyllia* are numerous, thin, often uniting and composed of vertical trabeculæ with vertical rows of perforations between them. It may be remarked that this lattice-work condition is not the result of fossilization or weathering, but that it is normal, and necessitates the species being placed with *Cyclolites* and other forms in a special family of the Fungidæ.

Turbinoseris has many species, and I have described them from the West Indies and from Sind, besides from the British Cretaceous. In all, the septa are solid, and that is sufficient to separate the two genera. *Turbinoseris* remains a member of the Lophoserine group

of the Fungidæ. *Turbinoseris de Fromenteli*, nobis, therefore retains its title, and Mr. Tomes cannot term it *Leptophyllia Anglica*, Tomes.

Mr. Tomes remarks (p. 545), "Some other compound corals have been collected at Haldon which, from their unsatisfactory condition, cannot be determined, though I believe them to be new. As the Haldon corals *are only casts*, they cannot be trusted when internal structure is important. The genus *Haldonia* is in my opinion a very doubtful one. Specimens in my own collection from Haldon differ in the important respect of sometimes having a styliform columella, and sometimes only a ring of pali, as in Prof. Duncan's figures." *Haldonia* was described and figured by me (Quart. Journ. Geol. Soc. 1879, vol. xxxv. p. 91), and like all the other forms I studied was *not in the form of cast*. *Haldonia Vicaryi*, nobis, was described from perfect specimens, and they had no columella. Corals of the same species, so far as my experience helps me, do not sometimes have a columella, and sometimes not and only pali. Probably the specimen seen by Mr. Tomes with a columella was the well-known *Actinacis* of Haldon.

I draw attention to the figures on the Plate (Geol. Mag. 1885, Pl. XIV. Figs. 14–15), and protest against species being determined from such fragments.

Finally, on looking at Fig. 13, which is said to represent a *Pleurosmilia*, it will be noticed that the columella does not terminate by uniting with one of the principal septa which is more developed than the others. The form does not belong to that genus, but to *Placosmilia*, Ed. and H.

Summary, Etc.

Smilotrochus insignis, nobis, non *Ceratotrochus insignis*.
——— *granulatus*, nobis, non *Trochocyathus Wiltshirei*.
Micrabacia Fittoni, nobis, non *Cyclocyathus Fittoni*, Ed. and H.
Podoseris mammiliformis, nobis, non *Rhizangia mammiliformis*.
——— *elongata*, nobis, non *Rhizangia elongata*.
Turbinoseris de Fromenteli, nobis, non *Leptophyllia Anglica*, Tomes.
Pleurosmilia neocomiensis, E. de From. fide Tomes, is *Placosmilia*.
Haldonia, nobis, has no columella.
Syzygophyllum, Reuss, non *Rhizangia*, Ed. and H.

III.—On the so-called "Gault" of West Dereham, in Norfolk.

By Clement Reid, F.G.S., and George Sharman.

(Published by permission of the Director-General of the Geological Survey.)

SINCE the publication of William Smith's Map of Norfolk in 1819, the sections around West Dereham and Shouldham have been accepted as proving the occurrence of true Gault[1] in this part of West Norfolk. Messrs. Rose,[2] Fitton,[3] and later writers, all

[1] The Kimmeridge Clay is also locally known as "Gault."
[2] Phil. Mag., series 3, vol. vii. pp. 171—182.
[3] Trans. Geol. Soc., series 2, vol. iv. p. 312.

accept this determination. Mr. Teall,[1] writing in 1873, points out the close relation of the fossils from the "Coprolite Bed" of West Dereham to those of the "Ammonites mammillaris zone" of Folkestone, and correlates the overlying blue marly clay with the Gault, from the occurrence in it of *Ammonites interruptus*.[2]

However, during the Geological Survey of this neighbourhood, great difficulty was found in separating the so-called "Gault" from the Chalk Marl, and after a minute examination of the whole district, the only boundary-lines which could be traced were, a distinct line of erosion below the "Coprolite Bed," and a lithological line where the hard Chalk rests on the Chalk Marl. Though close search was made for the more or less phosphatic bed which in many other parts of England marks the base of the Chalk, no trace of it could be found, and the conclusion could not be avoided, that the so-called Gault was both lithologically and stratigraphically merely part of the Chalk Marl.

The new Coprolite Works lately opened at West Dereham show the best sections of the Phosphate Bed, and of the Marl immediately overlying it; but the Marl there is very thin, being partly cut out by Boulder-clay. In October, 1883, the section seen in the well was:

		Ft.	in.
Chalk Marl	5. Boulder-clay, very chalky	7	0
	4. Blue Marl, drying bluish white	4	0
	3. Coprolite Bed	0	9
Neocomian ...	2. Hard loamy nodular Greensand	2	0
	1. Running Sand		

The other parts of the works are on lower ground, and show less Boulder-clay; though the Marl is about the same thickness, except in one place, where Boulder-clay cuts through it into the Greensand, and in other parts where the Coprolite Bed approaches the surface.

Taking the beds in order, No. 1 is undoubtedly Neocomian, though here it has yielded no fossils. No. 2 is probably also Neocomian, which has been slightly disturbed, reconstructed during the deposition of the overlying beds, and subsequently hardened by infiltration.

No. 3 is the bed for which the deposit is worked. It consists of a mass of phosphatic nodules in a greenish loamy or sandy matrix, partly derived from the underlying Neocomian Beds. Mixed with and occasionally imbedded in the nodules are numerous fossils. These fossils seem to be mainly derivative, for though most of them, as Mr. Teall has pointed out, belong to the zone of *Ammonites mammillaris*, there is apparently also an occasional admixture of older and newer forms, including some species, such as *Dentalium ellipticum*, probably belonging to the Gault.

The "Coprolite" occurs in this bed in two forms. The more abundant is a poor sandy phosphate in irregular nodules, which may have been partly formed in the bed itself. These seldom contain fossils. The associated mollusca are generally either loose casts, or are imbedded in a sandy matrix which has not been phosphatized,

[1] The Potton and Wicken Phosphatic Deposits, 8vo. pp. 20, 21.
[2] See also Keeping's Neocomian Deposits of Upware, etc., 8vo. pp. 11, 54.

though the shells themselves are usually coated internally with a smooth-grained black phosphate. Unfortunately, in so coarse a bed there is not much chance of finding the contemporaneous fauna preserved, and as nearly all the collecting has been done after the material has been roughly washed by machinery, any contemporaneous shells have probably been entirely destroyed. Collecting small fossils before the bed is washed is also very difficult, for it is impossible to see any, and the phosphate bed is not left to the action of the rain, but is immediately carted away.

Leaving, therefore, the Phosphate Bed, which, though stratigraphically merely the basement-bed of the overlying Marl, cannot yet be proved to be so by evidence of the fossils, the undoubtedly contemporaneous shells of the underlying 3 or 4 feet of Marl (No. 4 of the section) were carefully collected and examined. The result showed, that while at first sight there was abundance of evidence for the correlation of the Marl with the Gault, yet closer examination proved the Gault fossils to be derived, and the contemporaneous fauna to belong to the Chalk Marl.

The following is a complete list of the fossils obtained in the Marl at West Dereham Coprolite Works—nearly all of them were found within two feet of the Coprolite Bed :—

Pentacrinus, sp.
Pseudodiadema, spine.

Serpula, sp.

Terebratula biplicata, Sow.
Rhynchonella, sp.

Anomia, sp.
Exogyra haliotoidea, Sow.
Ostrea acutirostris, Nilss.
——— *vesicularis*, Lam.
Plicatula, sp.
Pecten orbicularis, Sow.
——— *quinquecostatus*, Sow.
Inoceramus, sp.
Lima, sp.

Nucula pectinata, Sow. (cast).
Pholadidœa? in wood.

Dentalium ellipticum, Sow. (casts).
Ammonites interruptus, Brüg. (casts).

Belemnites attenuatus, Sow.
——— *minimus ?* List.
——— *ultimus*, D'Orb.
Hamites, sp. (cast).

Beryx, sp. (in light-coloured phosphate).
Cymolichthys ? (*Saurocephalus*) *striatus*, Ag.
Odontaspis gracilis, P. & C.
Pycnodus, sp.

Of these the most conspicuous and easily found, except the *Belemnites*, is *Ammonites interruptus*, which is a characteristic Gault form. But this species, and also *Hamites*, *Dentalium ellipticum*, *Nucula pectinata*, *Pholadidœa*, and the fish are all phosphatized, and usually rolled. They are probably derived from the Gault. The rest are white and unphosphatized, and are all known from the Lower Chalk of other districts. Two, *Ostrea vesicularis* and *O. acutirostris*, have not been discovered below the Chalk.

Around West Dereham numerous trial-holes have lately been made to prove the Coprolite Bed, and most of these were still open while the Survey was in progress. Unfortunately, none of them show more than from two to four feet of the overlying Marl, nor do the old works appear to have exposed any deeper section. Everywhere *Belemnites attenuatus*, *B. ultimus*, and *B. minimus* ?, are abundant, and associated with them is often found the phosphatized *Ammonites interruptus*.

To obtain the fossils of the Marl unmixed with derivative forms, an old pit at Muzzle, about a mile W.N.W. of West Dereham, was searched. This locality has been mentioned by several writers as showing a typical exposure of Gault, and it is interesting to find that not a single characteristic Gault form occurred, but that there were several species which have not been recorded from below the Lower Chalk.

The section, which is very good, though the pit is now seldom worked, shows a nearly vertical face of obscurely bedded blue marl with small black phosphatic concretions. Belemnites are scattered promiscuously throughout. Several years ago a trial was made in this pit for the 'Coprolite Bed,' and it was reached three feet below the floor; but only a few nodules were found, and the bed was too thin to work. This section, therefore, is an upward continuation of the one at the new Coprolite Works, but the lower three feet of Marl being unworked, there is no complication from derived fossils. The following species were obtained, but no doubt longer search would soon add to the number:—

Pentacrinus, 2 sp.
Pseudodiadema, sp.

Serpula, sp.

Kingena lima, Defr.
Terebratulina gracilis, Schlot.
——————— sp.

Ostrea vesicularis, Lam.

Plicatula, sp.
Inoceramus, sp.

Ammonites (fragment).
Belemnites attenuatus, Sow.
——— *minimus*? List.
——— *ultimus*, D'Orb.

Fish vertebra.

All of these occur in the Chalk or Chalk Marl, and the same three *Belemnites* are found in the Red Chalk of Hunstanton, which has lately been shown probably to belong to the Lower Chalk.[1] Thus it seems that the so-called Gault of West Dereham all really belongs to the Chalk Marl, and in this part of Norfolk the Gault is only represented by its derivative fossils in the basement bed of the Chalk. This greatly simplifies the geology, as, instead of two unconformities close together, there is only one, the Chalk Marl having cut through the Gault, and having cut also a considerable depth into the underlying Neocomian.

There is a long dip-slope near West Dereham, which keeps the Coprolite Bed conveniently near the surface over more than a square mile. But the uncertainty of the dip renders it very difficult to estimate the thickness of the Chalk Marl, which may be only 20 feet or over 50 feet. Unfortunately, the bed can only be traced for a short distance. East of the Fenland it first rises above the marsh-level at Wretton, and extends about three miles to the north-west, to Crimplesham, with an outlier capping the hill at Muzzle.

At Crimplesham it is lost beneath the Boulder-clay for about three miles, but reappears south of Shouldham as a bluish marly Clay full of *Belemnites attenuatus*, *B. minimus*? and *Plicatula*. In

[1] See Whitaker, Presidential Address to the Norwich Geol. Soc. 1882, Proc. Nor. Geol. Soc. vol. i. pp. 207–236.

lithological character and fossils it is exactly like the Marl of West Dereham, but the Coprolite Bed, though searched for, could not be found. Only one section, in a deep ditch, could be examined; but the width of the outcrop shows that the Marl cannot be much less than 20 feet in thickness, though apparently thinner than at West Dereham.

IV.—The Lower Lias of Leicestershire.

By H. E. Quilter.

THE Lower Lias in Leicestershire commences with clays and limestones (Strensham Series), succeeded by clays and shales. In its palæontological characters, as well as in its petrological features, it agrees in the main with the Lias of contiguous districts.

The following life-zones are apparently represented, viz. zones of *Ammonites planorbis, angulatus, Bucklandi, semicostatus, oxynotus, armatus, Jamesoni* and *capricornus.*

The junction of the Rhætic beds and the Lower Lias may be seen at Wigston, near Leicester; this section has been fully described.[1] In the clay-pits at this place may be seen, resting upon Rhætic shales, about 9 feet of limestones and shales, containing a Liassic fauna.

A boring for Coal in 1883 at Crown Hill, near Leicester, after passing through Lower Lias limestones and shales, penetrated 26 ft. of Rhætic shales before reaching the Keuper.

Nowhere in the county, so far as I am at present aware, is the true relationship between the Lower and Middle Lias clays shown. The palæontological evidence of other exposures, however, favours the view adopted by the Geological Survey,[2] that the uppermost beds of the Lower Lias are those of the zone of *Am. capricornus.*[3]

Zone of *A. planorbis.*

The limestones and clays of this zone (the Fish, Insect, and Reptilian beds) are well exposed at Barrow-on-Soar, where they are shown to a thickness of 25 feet. The 9 feet of limestone and shales resting upon Rhætics at Wigston are the lowest portion of this zone.

(?) Zone of *A. angulatus.*

A bed of pyritous shale, nearly 18 feet thick, containing *Æg. catenatum*, overlying the beds of the Planorbis zone at Barrow-on-Soar, has been referred to as the representative of the zone of *A. angulatus.* The railway cutting on the Uppingham Road, near Leicester, exposed about 12 feet of blue pyritous shale, also containing *Æg. catenatum.*

Three or four feet of blue clays exposed in brickyards at Bottesford are supposed to belong to this zone. With this exception, there does not appear to be any exposure of the beds of this zone. The position of the thick pyritous clays will be referred to in general conclusions.

[1] Geol. Mag. Sept. 1884, p. 415.
[2] Mem. Geol. Survey. Geol. of Rutland, etc. J. W. Judd.
[3] This Ammonite was formerly considered to mark the *Middle* Lias (but see p. 86).

Zone of *A. Bucklandi.*

The beds of limestone and clay belonging to this zone are well exposed in the district. The chief sections being at Crown Hill, near Leicester, where nearly 50 feet of limestone and clay are exposed, and at Kilby Bridge, where about 36 feet of the same were shown. Exposures of a higher series of beds in this zone are given in a brickyard by the canal side, near Great Glenn Railway Station, showing 14 feet of dark-blue pyritous shales, with limestone nodules, full of fossils. At the time of writing, brickyards at Fleckney show from three to four feet of these clays.

During the excavations for the Great Northern Railway from Leicester to Tilton, about 12 feet of blue pyritous clays were cut through at the entrance of Ingarsby Tunnel.

Zone of *A. semicostatus.*

This zone is not now so well exposed in the Vale of Belvoir as during the Geol. Survey in 1874. When fully exposed, it was seen to be a thick hard band of ferruginous limestone. It is fossiliferous, but the present scarcity of exposures prevents any investigation.

Prof. J. W. Judd, F.R.S., in his Memoir gives a list of fossils.

Zone of *A. oxynotus.*

The shales of this zone could formerly be examined remarkably well at a tunnel between Grimston and Old Dalby, on the Notts and Melton Branch Railway. The section is now unfortunately covered up, but the heaps of *débris* on the top of the tunnel show thinly laminated blue shales, with ferruginous and limestone nodules, and shelly bands of limestone. The shales when weathered are, in places, richly fossiliferous, and judging from their present position on the shale heaps, there would appear to be a regular disposition of the fossils in bands or levels in the section, species of fossils being confined to one place or heap in the *débris.*

These shales with characteristic fossils are also exposed in a brickyard between Houghton and Billesdon. The section there shows about six feet of blue laminated shales, with pyritous bands, and scattered ironstone nodules, which are more numerous towards the top of the section.

Zone of *A. armatus.*

The beds of this zone are well exposed at Loseby brickyard and in the railway cuttings at Loseby Station.

The sections at both localities show about 26 feet of blue laminated shales, with numerous ironstone nodules, and a sandy indurated rock-bed about one foot thick near the base.

A similar section showing about 20 feet of shales with limestone and ironstone nodules, which appear to be in beds of this zone, is exposed at Loseby brickyard.

Zone of *A. Jamesoni.*

So far as I am aware, there are no good exposures of the beds of dark blue clays with septaria of this zone. They appear to be exposed in the brickyard at Woolsthorpe. During drainage opera-

tions near Woolsthorpe (August, 1884), about three feet of these clays were shown. Prof. Judd mentions exposures in the banks of the River Eye.

Zone of *A. capricornus.*

The beds of this zone were well exposed in a field dug for ballast during the recent alterations in the railway near Market Harborough. Six feet of blue shales with abundance of hard limestone nodules containing fossils were shown. Above these were seven feet of thickly laminated blue pyritous shales, containing ironstone nodules, and quite unfossiliferous. A small section of these latter beds is to be seen in a brickyard at the foot of the hill near Meville Holt.

TABLE OF FOSSILS.

SHOWING THEIR RANGE THROUGH THE ZONES.

SPECIES.	ZONE OF							
	A. planorbis.	*A. angulatus.*	*A. Bucklandi.*	*A. semicostatus.*	*A. oxynotus.*	*A. armatus.*	*A. Jamesoni.*	*A. capricornus.*
Plesiosaurus megacephalus	x	...	...	...	...	...	...	...
Ichthyosaurus communis, Conyb.	x	...	...	...	...	...	...	...
——— *tenuirostris*, Conyb.	x	...	...	...	...	...	...	...
——— *intermedius*, Conyb.	x	...	...	...	...	...	...	...
——— *platyodon*, Conyb.	x	..	...	...	...	...	...	...
(Saurian remains)	x	...	x	...	...	x	...	..
Dapedius orbis	x	...	...	...	...	...	...	...
Belonostomus acutus, Agass.	x	...	...	...	...	...	...	...
Pholidophorus Hastingsiæ	x	...	...	...	...	...	..	...
——— *Stricklandi*	x	...	..	...	...	...	...	...
——— *Egertoni*	x	...	...	...	...	...	...	...
Leptolepis sprattiformis (?)	x	...	...	...	...	...	...	...
(Fish remains)	x	...	...	...	...	...	...	. .
Ægoceras planorbis, Sow.	x	...	...	...	...	...	...	...
——— *Johnstoni*, Sow.	x	...	...	...	...	...	...	...
——— *tortilis*, D'Orb.	x	...	...	...	...	...	...	...
——— *catenatum*, Sow.	...	?	...	...	...	...	...	...
——— *angulatum*, Schloth.	...	...	x	...	...	...	...	...
——— *Charmassei*, D'Orb.	...	...	x	...	...	...	...	...
——— *polymorphum*, Quenst.	...	...	x	...	...	...	...	...
——— *Jamesoni*, Sow.	...	...	...	...	x	...	x	...
——— *Taylori*, Sow.	...	...	...	...	x	...	...	...
——— *Valdani*, D'Orb.	...	..	...	...	x	...	...	...
——— *Henleyi*, Sow.	...	...	...	...	x	...	...	x
——— *curvicornum*, Schloth.	...	...	...	...	x	...	...	...
——— *armatum*, Sow.	...	...	...	...	...	x	...	...
——— *striatum*, Rencke	...	...	...	...	...	x	...	...
——— *brevispinum*, Sow.	...	...	...	...	...	...	x	...
——— *capricornum*, Schloth.	...	...	...	...	...	...	...	x
——— *gagateum*, Y. & B.	...	...	...	...	...	...	...	x
Arietites Bucklandi, Sow.	...	...	x	...	...	...	...	...
——— *Sauzeanus*, D'Orb.	...	...	x	...	...	...	...	...
——— *obesulus*, Blake	...	...	x	...	...	...	...	...
——— *Conybeari*, Sow.	...	...	x	...	...	...	...	...
——— *scipionianus*, D'Orb.	...	...	x	...	...	...	...	...
——— *semicostatus*, Y. & B.	...	...	x	x	...	...	...	...
——— *ophioides*, D'Orb.	...	...	...	...	...	x	...	...

SPECIES.	ZONE OF							
	A. planorbis.	*A. angulatus.*	*A. Bucklandi.*	*A. semicostatus.*	*A. oxynotus*	*A. armatus.*	*A. Jamesoni.*	*A. capricornus.*
Amaltheus oxynotus, Quen.	...	...	...	...	x	...	...	...
Phylloceras Loscombi, Sow.	...	...	...	...	x	x	...	...
Lytoceras fimbriatum, Sow.	...	...	...	...	...	...	...	x
(*Ammonites latæcosta*, Sow.)	...	...	...	...	...	...	x	...
(——— *Normanianus*, Sow.)	...	...	...	...	...	...	x	...
Nautilus striatus, Sow	x	...	x	...	...	...	...	...
——— *truncatus*, Sow	...	...	...	...	...	x	...	...
Belemnites infundibulum, Ph.	...	...	x	...	...	...	...	...
——— *acutus*, Mill.	...	...	x	x	?	x	...	...
——— *elegans*, Simps.	...	...	...	...	x	...	...	...
——— *clavatus*, Blainv.	...	...	...	...	...	...	...	x
Dentalium, sp.	...	...	x	...	...	...	...	...
Cryptœnia consobrina, Tate.	...	...	..	...	x	...	...	...
——— *expansa*, Sow.	...	...	...	x	x	...	...	..
Pleurotomaria anglica, Sow.	x	...	x	...	x	...	...	...
——— *precatoria*, Desl.	...	...	...	x	...	...	...	...
——— *princeps*, K. & D.	..	...	...	x	...	...	...	...
Trochus Thetis (?), Münst.	...	...	...	...	x	...	...	...
——— *imbricatus*, Sow.	...	...	...	x	...	...	...	...
——— sp.	...	...	...	x	...	...	...	...
Turbo Dunkeri, Münst.	...	...	x	...	...	...	...	...
——— sp.	...	...	...	x	...	...	...	...
Eucyclus Gaudryanus, D'Orb.	...	...	...	...	x	...	...	...
——— ,, var. (?)	...	...	...	...	x	...	...	.....
——— *conspersus*, Tate	...	...	...	...	x	...	...	...
——— *elegans*, Münst.	...	...	x	...	...	x	...	...
Turritella, sp.	...	...	...	...	x	...	...	...
Cerithium liassicum, Moore	...	...	...	...	x	...	...	...
——— *varicosum*, Moore	...	...	...	...	x	...	...	...
——— *asperulum*, Moore	...	...	...	...	x	...	...	...
——— *Ibex*, Tate	...	...	...	...	x	...	...	...
——— *ligaturalis*, Tate	...	...	...	x	...	...	...	...
——— *subfistulosa*, Tate	...	...	...	x	...	...	...	...
Chemnitzia Blainvillei, Münst.	...	...	...	...	x	...	...	...
——— *semitecta* (?), Tate	...	...	...	...	x	...	...	...
——— *citharella*, Tate	...	...	...	...	x	...	...	...
——— *carusensis* (?), D'Orb.	...	...	...	...	x	...	...	...
——— *Berthaudi*, Dunn	...	...	...	...	x	...	...	...
Acteonina, sp.	...	...	...	...	x	...	...	...
Ostrea Liassica, Strick.	x	?	x	...	x	?	...	x
——— *Goldfussi*, Bronn.	...	...	...	...	...	x	...	...
Gryphea arcuata, Lam.	x	?	x	x	x	x	...	...
——— *cymbium*, Lam.	...	...	...	...	...	...	x	...
——— *obliquata*, Sow.	...	...	...	...	...	...	x	...
——— *Macullochi*, Sow.	...	...	...	...	x	...	...	...
Pecten lunularis, Römer	x	...	x	...	...	...	...	...
——— *textorus*, Schloth.	...	...	...	x	...	...	...	...
——— *equivalvis*, Sow.	...	...	...	x	x	...	...	...
——— *Liasianus*, Nyst.	...	...	...	x	...	...	...	...
Lima succincta, Schloth.	x	...	x	...	...	...	...	...
——— *Hermani*, Voltz.	x	...	...	...	...	x	x	...
——— *gigantea*, Sow.	x	?	x	x	?	x	...	...
——— *pectenoides*, Sow.	x	...	x	x	x	x	...	...
——— *punctata*, Sow.	...	...	...	x	...	...	...	...
——— *acuticosta*, Schloth.	...	...	...	...	...	...	x	...
Limea, sp.	...	...	x	...	...	...	...	...

SPECIES.	ZONE OF							
	A. planorbis.	*A. angulatus.*	*A. Bucklandi.*	*A. semicostatus.*	*A. oxynotus.*	*A. armatus.*	*A. Jamesoni.*	*A. capricornus.*
Plicatula spinosa, Sow.	...	...	x	...	x	x	x	...
—— *lævigata*, D'Orb. (?)	...	...	...	...	...	...	x	...
Avicula (*Monotis*) *cygnipes*, Y. & B.	..	...	...	...	...	x	...	...
Perna infraliassica, Quen.	...	...	x	...	...	...	...	...
Inoceramus ventricosus, Sow.	...	...	...	...	x	...	...	...
Pinna folium, Y. & B.	...	...	...	...	x	x	...	.
Modiola minima, Sow.	x	...	...	...	...	...	...	...
—— *lævis*, Sow.	...	...	x	...	...	...	...	...
—— *Hillana*, Sow.	...	..	x	x	...	...	...	...
—— *Morrisii*, Oppel.	...	...	...	x	...	...	...	...
—— *scalprum*, Sow.	...	...	x	...	x	x	?	x
Nucula variabilis, Quen.	...	...	...	...	...	...	...	x
Leda galathea, D'Orb.	..	...	..	...	x	...	...	x
—— *minor*, Simps.	...	...	...	...	x	...	...	...
—— *complanata*, Goldf.	...	...	...	...	x	...	...	...
Cardinia Listeri, Sow.	...	...	x	...	x	...	...	..
—— *gigantea*, Quen.	...	...	...	x	...	...	...	...
—— *copides*, Ryck.	...	...	...	x	...	...	...	...
—— *hybrida*, Sow.	...	...	...	x	...	...	...	...
—— *ovalis*, Stutch.	...	...	...	x	...	...	...	...
Cypricardia cucculata, Mün.	...	...	...	...	...	x	...	...
Hippopodium ponderosum, Sow.	...	...	x	...	x	x	...	...
Protocardium Phillipianum, Dunk.	...	...	...	...	x	...	...	...
Unicardium cardioides, Phill.	...	...	x	x	x	x	x	...
Pholadomya glabra, Agass.	...	...	x	...	...	...	...	...
—— *ventricosa*, Agass.	...	...	...	...	x	...	...	...
—— *ambigua*, Sow.	...	...	...	...	...	x	...	...
—— *decurata*, Hartm.	...	...	...	...	...	...	x	...
Goniomya hybrida, Münst.	...	...	...	...	...	...	...	x
Pleuromya striatula ...	...	...	x	...	x	...	...	...
—— *unionides*, Röm.	...	...	...	x	...	...	...	...
—— sp.	...	...	...	...	x	...	...	...
Arcomya vetusta, Phil.	...	...	...	...	x	...	...	...
Spiriferina Walcotti, Sow.	...	...	...	...	x	...	x	...
—— *verrucosa*, V. Buch.	...	...	...	...	x	...	...	...
Terebratula punctata (?), Sow.	...	...	...	x	...	...	...	...
Waldheimia numismalis, Lam.	...	...	...	...	x	...	...	...
—— *perforata*, Piette	...	...	x	...	...	x	...	...
Rhynchonella plicatissima, Quen.	...	...	x	...	x	x	...	...
—— *tetrahedra*, Sow.	...	...	...	...	x	...	...	...
—— *variabilis*, Schloth.	...	...	...	x	...	...	...	...
Buprestis (Elytron of), Brodie	x	...	...	...	...	...	...	...
Libellula (Wing of), Brodie	x	...	...	...	...	...	...	...
Eryon Barroviensis, M'Coy	x	...	...	...	...	...	...	...
—— sp.	...	...	x	...	...	...	...	...
(Crustacean remains)	...	...	...	...	x	...	...	...
Serpula capitata, Phill.	...	...	...	x	...	...	...	...
—— (species of)	x	...	x	...	x	x	x	...
Cidaris Edwardsii, Wrt.	x	...	x	...	?	...	...	...
Hemipedina Tomesii, Wrt.	x	...	...	...	...	...	...	...
Pentacrinus psilonoti, Quen.	x	...	x	...	...	...	...	...
—— *punctiferus*, Quen.	...	...	...	...	...	...	x	...
—— *robustus*, Wrt. ...	...	...	...	...	...	...	...	x
Montlivaltia Guettardi, Blain.	...	...	x	...	...	...	...	...
—— *mucronata*, Dunc.	...	...	...	...	x	...	...	...
Lepidophyllia Hebridensis, Dunc.	...	...	...	x	...	...	...	...

Mr. E. Wilson, F.G.S., who has rendered me great assistance in the above list, also informs me that he detected *Foraminifera* in several of the Lower Lias clays of the district; in particular from the *A. oxynotus* shales at the Tunnel near to Old Dalby Station, from whence he has obtained no less than thirty forms, the following genera being represented:—

Nonionina.	*Planularia.*	*Nodosaria.*
Frondicularia.	*Textularia.*	*Marginulina.*
Involutina.	*Dentalina.*	*Cornuspira.*
Lingulina.	*Cristellaria.*	*Miliola.*
Pulvinulina.	*Orbulina.*	

General Conclusions.

Considering the few and comparatively unimportant exposures of these rocks in Leicestershire, and the consequent difficulty of obtaining a complete series of fossils, a classification of the beds into life-zones would seem hardly feasible. Sufficient has been done, however, to make the case good. Nevertheless, it would be premature at present to make any deductions with regard to the passage of important species from one zone to another.

The apparent non-development of the zone of *A. angulatus*, and the intercalation of the zone of *A. semicostatus*, with the zones of *A. Bucklandi* and *A. oxynotus*, may perhaps be made the subject of remark. That the beds of the zone of *A. angulatus* are present is highly probable.

Mr. J. D. Paul, F.G.S., informs me that 186 feet of Lower Lias limestones and clay were passed through in the boring at Crown Hill, near Leicester. Deducting from this, say 40 feet, for the maximum thickness of the beds belonging to the zone of *A. planorbis*, and 60 feet for the thickness of the lower beds of the zone of *A. Bucklandi*, which are, as already mentioned, exposed here, about 86 feet of the beds passed through in the boring remain to be accounted for.

As bearing on this point, I would here note the similarity of the sections at Kilby Bridge and Crown Hill, and the occurrence of *Æg. angulatus* in the lower beds of these exposures, showing that these beds are not far from the junction of the zones of *A. angulatus* and *A. Bucklandi*.

The 86 feet, or thereabouts, remaining to be accounted for, may reasonably be assigned to the zone of *A. angulatus*. The thick bed of clay exposed at Barrow-on-Soar, and in the railway cutting on the Uppingham Road, near Leicester, has also been thought to represent the zone of *A. angulatus*; but if my supposition be correct, this is not so.

The fauna of this bed is so scanty, containing only *Æg. catenatum*, *Lima gigantea*, and *Gryphea arcuata* (the two latter being dwarf forms), that we can learn nothing from it; but the occurrence of *Æg. catenatum* in this bed only is peculiar and interesting. *Æg. catenatum* appears to be an evolutionary form between *Æg. planorbis* or *Æg. Johnstoni* and *Æg. angulatum*.

From this, I assume this thick bed of clay to be a bed containing

a transition fauna between the zones of *A. planorbis* and *A. angulatus*, not so well developed perhaps in other districts.

Under these circumstances, should the zone of *A. angulatus* be eventually exposed, and with more exposures, an assemblage of fossils be found in the clays containing *Æg. catenatum*, then those clays should be placed in the position of a subzone—the subzone of *A. catenatum*. For the present, however, it might be termed the "Catenatus bed," and separated on those grounds from the zones of *A. planorbis* below and *A. angulatus* above.

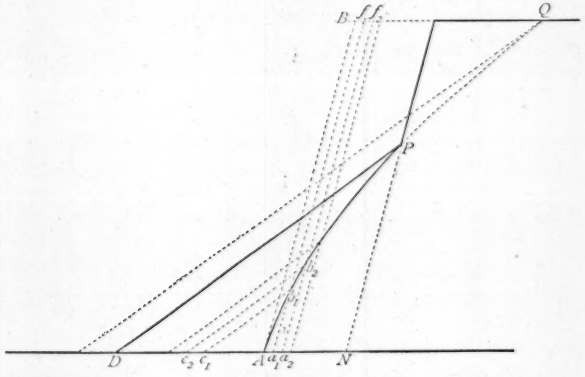
The occurrence of the interesting zone of *A. semicostatus* is an example of the fluctuations of the zones of the Lias formation in districts or areas, and how species perhaps only of secondary importance in one zone, under certain conditions of environment may be of capital importance in another.

I have to acknowledge the assistance of Prof. Blake, of Nottingham, who has kindly determined many of the fossils for me, and also that of Mr. E. F. Bates, of Leicester.

V.—Note on the Form of the Uneroded Surface of Rock underneath a Talus.

By Charles Davison, M.A.;
Mathematical Master at King Edward's School, Birmingham.

In the case of a vertical cliff, Mr. Fisher has shown that the uneroded surface of rock underneath a talus is in the form of a semi-parabola.[1] The object of this note is to show that the form is parabolic, even if the cliff be not initially vertical, assuming, with Mr. Fisher, (1) that the cliff-face is weathered uniformly at all points, and (2) that the disintegrated material is spread evenly over the surface of the talus, so as to maintain it always at the same slope. The proposition may be proved analytically, as in Mr. Fisher's paper, or geometrically as follows.



[1] Rev. O. Fisher, "On the Disintegration of a Chalk Cliff," Geol. Mag. (1866), Vol. III. pp. 354–356.

Let AB, the original face of the cliff, be inclined at an angle α to the horizon. In any given interval of time, suppose the layer ABf_1a_1 to be worn from the face of the cliff, and the material spread at the foot of the cliff as $a_1b_1c_1$, the surface b_1c_1 being plane and inclined to the horizon at an angle β. Let $AB=h$, $Aa_1=x_1$, $a_1b_1=y_1$.

Now, the parallelogram ABf_1a_1 is equal to a rectangle whose base is Aa_1 and height $h \sin \alpha$,

$$\therefore \text{ area } ABf_1a_1 = hx_1 . \sin \alpha,$$

and triangle $a_1b_1c_1 = \frac{1}{2} a_1c_1 . a_1b_1 . \sin \alpha$,

$$= \frac{1}{2} a_1b_1 . \frac{\sin(\alpha-\beta)}{\sin \beta} . a_1b_1 . \sin \alpha,$$

$$= \frac{1}{2} y_1^2 . \frac{\sin(\alpha-\beta) \sin \alpha}{\sin \beta}.$$

$$\therefore y_1^2 = \frac{2h \sin \beta}{\sin(\alpha-\beta)} . x_1.$$

During a second interval, equal to the first, let another layer of the same thickness be worn from the face of the cliff b_1f_1, and be deposited over the *débris* at the base, and inclined at the same angle β to the horizon, so as to raise the surface of the talus to b_2c_2. Let $a_2b_2=y_2$, and $Aa_2=x_2=2x_1$.

Now, area $f_1b_1b_2f_2 = (h-y_1)\, x_1 . \sin \alpha$,

and area $c_1c_2b_2b_1 = a_2b_2c_2 - a_1b_1c_1 - a_1b_1b_2a_2$,

$$= \frac{1}{2} y_2^2 . \frac{\sin(\alpha-\beta) \sin \alpha}{\sin \beta} - \frac{1}{2} y_1^2 . \frac{\sin(\alpha-\beta) \sin \alpha}{\sin \beta} - y_1 x_1 \sin \alpha$$

$$\therefore \frac{1}{2} y_2^2 . \frac{\sin(\alpha-\beta)}{\sin \beta} = hx_1 + \frac{1}{2} y_1^2 . \frac{\sin(\alpha-\beta)}{\sin \beta} = 2hx_1.$$

$$\therefore y_2^2 = 4h . \frac{\sin \beta}{\sin(\alpha-\beta)} . x_1 = 2h . \frac{\sin \beta}{\sin(\alpha-\beta)} . x_2$$

Proceeding in this way, we see that after n layers have been worn away, we have

$$y_n^2 = 2h . \frac{\sin \beta}{\sin(\alpha-\beta)} . x_n.$$

Now, let each interval of time be supposed very small; then the layer disintegrated during each interval is very thin, and the form of the rock under the talus is a curve which has the property

$$PN^2 = 2h . \frac{\sin \beta}{\sin(\alpha-\beta)} . AN,$$

and is therefore part of a parabola whose axis is horizontal. The initial face of the cliff is a tangent to the curve at A, and the final surface of the talus, when it reaches the top of the cliff at Q, is a tangent to the curve at that point.

VI.—The Succession of the Later Tertiaries in Great Britain.

By Alfred Bell.

THOSE interested in the geology of the Upper Tertiaries must have noticed the divergence in the views entertained by different writers as to the succession of the various strata of which they are composed. Sundry causes may be assigned for this, such as the disposition in some quarters to regard the "lapse of time occupied in the accumulation of even our later Tertiary deposits" "as representing but a very brief chapter in geological history,"[1] or the massing of the several groups of strata in bulk, or putting aside as of little value the organic evidence they contain, which, even where this is appealed to, is too narrowly treated, as where one author—a specialist in his own branch—asks, "Could the more modern Tertiaries be classed by their Invertebrata?"

Not alone perhaps; but if all kinds of life are studied in correspondence with their surroundings, a natural sequence can be traced throughout their entire history.

Astronomical speculations as to the time when the Glacial epoch commenced or terminated, and the attempts thereby to determine the existence of Man upon the Earth, may be set aside as of little value at present; as Mr. Prestwich happily puts it, "the difficulties arising from astronomical theories are that they differ so much among themselves."[2]

A fair inference as to the time required may be drawn from the fossils. My lists give of the Eocene about 2500, and of the later Tertiaries above 3000 species, hardly any being in common.

In the following notes I have assumed that the constituents of the different deposits and their fossils are pretty well known to geologists, and I have therefore not attempted to locate *every* known bed, but to indicate the lines on which their classification is possible. A comparison betwixt that which I have here attempted and that adopted by Mr. J. Geikie will, I may say at once, indicate how widely divergent our respective views are. I take his as a standard of comparison as being the most extensive one brought forward hitherto.

I am probably biassed, but I cannot see any evidence in favour either of the numerous mutations of the surface, or alternate procession of the Northern and Southern Mammalia suggested in the "Great Ice Age," or that Britain was *ever otherwise than Continental* from the close of the Middle Red Crag age to that of the minor glaciation, about which time I consider it ceased to be so.

It may be laid down as a general rule that the fauna and flora march with the climate, *i.e.* cold with cold or the contrary, and that if by any possibility the temperature of any period can be ascertained, a corresponding organic life existed, circumstances being favourable thereto.

Of the preglacial deposits the admirable memoirs by Messrs. Clement Reid and E. T. Newton leave little to be said. I may, however, remark that the evidence of the Forest Bed being overlapped

[1] Dr. H. Woodward, On *Rhytina gigas*.

[2] Quart. Journ. Geol. Soc. vol. xxvii. p. 233.

by the Bure Valley Beds is not so satisfactory as might be desired. I am more disposed to agree with Mr. H. B. Woodward in placing these marine beds on the same level as the Weybourne Sands, and as constituting the very upper part of the newer Pliocenes, since I find that, with the exception of *Tellina balthica*,[1] all the mollusca of these beds are found in the Butley Crags.

The Quaternary, if not a very sound division of the Tertiary, is at least a very convenient one, and it is with the "Forest Bed" rather than the preceding Passage beds that it may be said to commence.

Mr. H. B. Woodward takes the view that the lapse of time between the Newer Crag and the Forest Bed may be inconsiderable; but there is not only the disappearance of the *Mastodon* to be accounted for, but the variation in the Mammalia as a whole; since, leaving out nine species in the Norwich Crags still existing, only four pass up to the Forest-bed, where at least 40 others occur for the first time. (Is there any confirmatory evidence of the existence of *Mastodon* in the later Thames gravel as recorded by Mr. Whitaker? Mem. Geol. Survey.)

The fluviatile mollusca, except for *Lithoglyphus*,[2] does not offer much for comment. The splitting up of the very minute Hydrobia by Sandberger into so many new species and a new genus will not commend itself to Conchologists generally.

Will Mr. Reid allow me to set one of his quotations right? I am represented as saying (Mem. Country around Cromer, p. 74) that Mr. Prestwich's *Unio margaritifera* in reality is *Unio littoralis*. If he will turn to the Geol. Mag. Vol. IX. 1872, p. 214, he will find *I said nothing of the kind, but that it was an Anodon*, as he himself assigns it. The specimen referred to is in the Norwich Museum. Again, on what grounds does he transfer the *Limax agrestis* of my Forest Bed list to *L. modioliformis?* The Forest Bed Mollusca I collected myself. *Silpha dispar* may be also added to the Coleoptera.

Inasmuch as Mr. Newton has rehabilitated in the Forest Bed *Hyæna spelæa* after having once rejected it, I hope he will be able also to replace the other species he has excised from the Forest Bed list compiled by my brother and myself.

Between the temperate Forest Bed flora and the intensely Arctic one above it the measure of time must be a long one to allow for physical changes, as the Forest Bed must have been submerged at least six or eight fathoms, that being the average depth at which the Yoldias found *in situ* in the intervening beds inhabit our modern seas, the Yoldia or *Leda myalis* beds being here 15 feet thick.

One of the chief objections to the Myalis bed being synchronous with the Bure Valley Beds is the fact that several of the species, *Leda*

[1] The presence of this shell seems to indicate that great hydrographical changes had taken place, probably the influx of a heavy current setting in from the north, bringing the Tellen in profusion. It sufficiently distinguishes the beds in which it occurs from the immediately preceding Upper Crag or the Chillesford Series.

[2] This is the recent species figured in Forbes and Hanley's British Mollusca as *Natica Kingi*, obtained in the rubbish of a fishing boat at Cullercoats.

included, are found in their living position. It may be also worth noting that the *Leda myalis* does not occur in the inland Bure Valley Beds or the Weybourne Crags, where *L. oblongoides* (*L. limatula*) is the representative species, and of the 18 Bure Valley marine species, eight do not occur in the Myalis Bed; and of the 15 species in the latter, nine are not found in the Bure Valley.

I may call Mr. Reid's attention to a very valuable paper by Dr. Nathorst, on this Arctic plant-bed, in vol. iii. of the Journal of Botany, London, which Mr. Reid seems to have overlooked (*op. cit.* p. 83), in which the Doctor records the species he obtained, including a large number of Willows and Mosses now living only within the Arctic circle.

It is generally assumed that a great elevation of the land was taking place throughout the earlier part of the major glaciation, culminating in a rise to at least the 100-fathom line, raising the whole bed of the North Sea, except a narrow valley towards the Norway coast—the ice-sheet then generated not extending to the South of Britain. Of the land or sea life of this period there is no record in Britain, but it may be surmised that the Mammoth and *Rhinoceros tichorhinus*, the Wolverine and the Musk Sheep roamed the frozen solitudes in scanty numbers. That which would be most consonant with the climate is found in the masses transported bodily from some unknown deep-sea locality, imbedded in the higher Yorkshire Clays at Bridlington and elsewhere (*vide infra*), the few fragments mentioned by Mr. Reid from the Cromer Drift being doubtfully *in situ*.

Subsidence of the land is indicated by the erosion prior to the deposition of the wide-spread sheets of Middle Glacial sand and gravel extending from Shropshire to Belgium (if, as Mr. S. V. Wood suggested, the Sables de Campine are of this age). These sands are mainly, and I am inclined to think altogether, unfossiliferous. The very fragmentary condition of the large number of species (94) recorded by Mr. Wood from these sands, and the fact that except six or seven all are present in the Butley Crag, induce me to think, contrary to the opinion of the Messrs. Wood and Harmer, that, like the corresponding sands of Slains and Cruden, containing fragmentary Red Crag shells, they are purely derivative.[1] It is also difficult to see where such a fauna could have existed in continuity throughout the preceding stages, if the bed of the North Sea had been elevated to the extent supposed. These sands and gravels are apparently due to the floods let loose by the melting ice, excessive rainfall, and the sorting action of the sea as a greater area was brought under its influence while the land slowly subsided. The immense influx of freshwater would be unfavourable to the development of marine life which in the Anglo-Belgian Gulf had ceased to exist, the incoming northern fauna being unmodified by southern accretions till the future minor glaciation had passed away, and the communication re-opened between the Channel and the North Sea.

[1] Traces of Red Crag Shells, *Pecten opercularis*, have also been found in the westerly extension of the Middle Glacial.

On the western side of Britain a different set of conditions obtains in the beds beneath the Till in Kilmaurs, Tangy-Glen, and elsewhere. Of the 22 species recorded, 17 are still British; but the remaining five are extra-British, new to the fauna, and of true northern types corresponding to those on the east coast of Bridlington and Fife, as will be discussed presently.

The climax of the Glacial epoch occurs with the Great Chalky Boulder-clay, the true Scottish Till, the drift and unfossiliferous Till of the Midlands and north-west from Lancashire to Shropshire. From the presence of occasional horns, bones, and teeth in the Scottish clays, the remission at times of the intense cold may be inferred, as in the Greenland summer. I have no knowledge of the Crofthead Peat, except from the kindness of Mr. Mahoney, and his and Mr. Geikie's papers in the Geol. Mag. Vol. II. 1869; but, considering all the evidence, I am less inclined to regard it as an intercalated deposit in the Lower Till than as occupying a depression at its immediate close, the overlying drifts corresponding more to the higher English Purple Clays than to true Till. The fauna and flora, including *Bos primigenius*, are certainly not Arctic, as they should be if Greenlandic conditions prevailed.

The Purple Clays of Yorkshire and Lincolnshire mark the close of the first Glacial epoch in Britain. The researches of Mr. Lamplugh have definitely settled the question as to the fauna of the intercalated masses of sand and clay in the basement beds not being in position. Of the 120 molluscs on record from Bridlington,[1] I find on analysis that 39 are confined to these sands, and of the others, 22 are now extra-British, all of the species being still existing. The age when these molluscs lived would probably be about the time when the Arctic plant-bed was forming on the now Norfolk coast, the *Nucula Cobboldiæ* and *Tellina obliqua* linking it to the Newer Pliocene fauna, their habitat in the deep North Sea not far removed from shore—a few miles perhaps—similar to the Dogger and Antrim turbot banks, where northern forms still exist. Mr. Dawson records a similar deposit about eight miles off Cruden, from whence his dredge always brought up dead shells of northern types; of the seventeen species recorded, nearly all are found at Bridlington, and like deposits are not uncommon elsewhere. The Bridlington fauna is essentially a deep-sea one, and in *no case* could have originated or formed in any of the deposits of the Glacial epoch in Britain.

With the gradual cessation of Arctic conditions, depression began again, lasting until the waves of the Atlantic washed the shores of a coast-line extending in an irregular tract from the Severn to the Tees, accompanied by excessive thermal changes and the inbringing of a new series of life forms. Eliminating all the Bridlington species as of doubtful British origin, and all land and freshwater mollusca on either side from the list of species *before* and *after* the major glaciation treated of above, there remain of the Newer

[1] Dr. Jeffreys in working up the list of species in Mr. Lamplugh's paper omitted any reference to Mr. S. V. Wood's, and many other notices on the fauna.

Pliocene (Butley horizon[1]) 130 species which do not pass the barrier replaced by 160 others; forty to fifty again of these dying out on or before the succeeding minor glaciation. Mr. Crosskey points out "that the fossiliferous sands, etc., belong to several ages, the contents indicating several groups, having their own place in the gradual transition from a severely arctic to a more moderate temperature." This transition I am trying to illustrate. The oldest of the Interglacial marine deposits occur in the flanks of the Boulder-clay in Fife and Aberdeen, and, as might be expected, yield 22 extra-British species, of high Arctic types. After these may be grouped such beds as those of Bute and Arran, containing *Saxicava Norvegica*, and other boreal forms, without or with but a small proportion of more Southern forms, as at Paisley and Dalmeny later on.

Unless the raised beach at Portland Bill is of this age, there is no Marine deposit in South Britain that can be, so far as I am aware, correlated with this older group of Interglacial deposits; and the Lower Boulder-clays of Lancashire and the West containing *Cytherea Chione* are approximated by this shell to a slightly more recent period antecedent to the Middle Lancashire Sands.

The land fauna of this immediate Post-glacial age in Britain is very limited, the Mammoth, Woolly Rhinoceros, *Bos primigenius*, and the Reindeer, a new arrival, alone indicating the larger life in the north; but with the disappearance of the ice in lower lands, immigration began. Traces of such are found in the breccia of Kent's Hole, and the corresponding earth of the Brixham Windmill Caves, in the abundant relics of Cave Bear and the very rare Lion and Fox (White Fox) (1 jaw of each) and, as shown by his implements, Man. The presence of these four Carnivora is indicative of the herbivora, none of which has as yet been found, and Mr. Pengelly would probably be quite right in his argument that Man arrived in Britain before the Cave Hyæna, if he had added "after the Glacial epoch." From all the facts of our present knowledge there seems no escape from making the earliest *Primæval Man* (revealed by his works in a Devonshire Cave, *for the first time* on record), an Old Devonian and a real *homo*, having nothing to do with the Eocene Ape Man of Thenay, or his Miocene brethren of the Cantal and the Tagus.[2]

[1] I have used this horizon as a standard of comparison throughout, because of its accepted freedom from extraneous forms; and its richness in life offers sufficient ground for such reference.

[2] The evidence of Preglacial Man in England is confined to the Red Crag, and consists, 1st, of a shell with a supposed human face carved thereon (H. Stopes); 2nd, perforations in sharks' teeth (E. Charlesworth); 3rd, a human jaw deeply stained with iron from Foxhall (Dr. Collyer, Anthrop. Review, 1867, p. 221); 4th, a spear-head from a Coprolite heap, locality unknown (R. J. Mortimer, now in Brit. Mus.); and lastly, a specimen of apparently cut bone in possession of Prof. Prestwich (Nature, vol. xvii. p. 105). Of these the shell is probably like many other Walton shells fancifully decorticated; 2nd, the perforations are shown by Prof. Hughes to be due to animal action; 3rd, the jaw is repudiated by nearly all scientific men as of Preglacial age, although certainly old; 4th, Mr. Mortimer's implement has been fashioned since the fossilization of the bone. Mr. Prestwich's I have not seen. The absence of Palæolithic Mammals and Implements in either Scotland or Ireland is strong evidence in favour of an equal absence of dry land there.

The submergence of the north-west corresponds with the emergence or elevation of the east, and in the Glacial beds thus exposed the Thames river channel was opened, the oldest portion from East London to Ilford, Grays and Crayford, opening southwards (S. V. Wood), and at a later period, when the North Sea was resuming its old bed [inhuming the Mammalian fauna, brought up so frequently from its bottom by fishermen], the present channel in its entire length opening eastwards. These earlier gravels and brickearths yield a fauna indicating warmer conditions than now or at any time since the preceding glaciation. Grouped with these must be the rich Barnwell river gravels, containing more extra-British freshwater and land shells than all the other Post-Tertiary deposits put together, including *Helix fruticum, the only other* Post-Tertiary locality for which shell is Stutton on the Stour, a deposit of similar age, from whence the late Mr. S. V. Wood, sen., obtained the specimen (the only one) figured in Mon. Crag. Moll. I notice here this shell more particularly, because I shall have to call attention to certain erroneous references in respect to this species. The well-known deposit at Clacton Cliff belongs to this series: and here I must demur to Mr. Dalton collating the fauna at this place with that of Copford, especially without due revision. The Copford shells were named by one of the most competent men of his day, the late Mr. John Pickering, from Dr. Gray's edition of Turton's Manual, and the Clacton list by Mr. J. de C. Sowerby, in which two species are described as new, one being from the figure a variety of *Helix hispida*, and the other, judging from the description, a young *Planorbis glaber*. Mr. Sowerby used a different nomenclature from Mr. Pickering, and the incorporation of both lists into one without the elimination of the synonymic names unduly inflates the list of species (Memoirs of the Neighbourhood of Colchester, 1880).

The Worcestershire Avon gravels may be assigned to this series also, as, like the older Thames beds, the fauna of all kinds is marked not only by forms of southern types, but by an almost complete absence of northern and arctic species. The Musk Sheep would seem not to be in accordance with this view; but at present I should consider its occurrence at Crayford, Erith, and Freshford near Bath, to correlate these beds with the same age as the later Thames gravels near Maidenhead, when the declining was gradual. The Thames Valley is not a valley of one aspect or geologic stage, but many; the great river and its affluents, and the contents of the bordering gravels and soils sufficiently attest this. Mr. Worthington G. Smith[1] points out that three stages at least in the manufacture of palæolithic flints are traceable, ranging from the crudest to delicate tools of beautiful fabrication.

Coincident with the river earths above referred to, is the ancient peat of Lexden, near Colchester, where the Rev. O. Fisher obtained so many traces of mired and mud-bound Mammals, and an Insect fauna of trans-pyrenean growth.

[1] *Nature*, xxvii. p. 270.

The fauna of the "Mud Deposit" at Selsey, unfortunately so seldom visible, is exceedingly rich, as is well known, in shells of this age and character. The gravel beneath it is rich in land shells, but so rarely viewed as to be almost unknown. As described elsewhere by myself, I have taken from the mud bed 140 species of shells; of these about 30 do not come north of the Channel Islands or the north of Spain, eight being exclusively Mediterranean forms.

This extension northwards of southern types is visible very notably in the Middle Sands of the North-West of England and Wales, in the Shropshire and Severn gravels, etc. Undoubtedly all these are not of one age, but belong to various periods of the great submergence, as already indicated for the Scottish fauna. The given fauna from these beds is rich, almost too rich, for there is a shrewd suspicion that all the species quoted are not genuinely native, especially when obtained from the workmen. Many quarrymen unhesitatingly bring recent *Naticas* and other species, some with Confervæ on them, as the product of the soil. Mr. Darbishire, Mr. Maw, and myself in a small way have found this, even to the offering of the pearl oyster and other West Indian species.

Apart from this, the beds exhibit *Venus Chione* and other southern shells (and in Ireland *Woodia digitaria*) at higher latitudes than those they are now found living in. The finest and most instructive series, because almost every specimen has been obtained under the supervision of the owners of the gravel pit from whence they were exhumed, and preserved with great care, is that in the possession of the Misses ffarrington, of Worden, Lancashire, in which every species known to the N.W. gravels is contained with many others confined to this pit alone. When, by the kindness of the Misses ffarrington, I had the pleasure of working out the entire series, I found that from 130 to 140 species were represented, and it was not only in the number of southern species, but the southern exuberance of form and sculpture put on by such shells as *Murex erinaceus*, still with us, that testified to the extension northward, and the consequent indication of the southern climate that these showed.

Western currents were at times probably prevalent, since the finding of a West Indian Olive (*O. jaspidea* apparently from Strickland's drawing) and *Bulla ampulla*[1] in the Severn drift implies as much.

I can identify only two deposits in the West of Scotland with this series—Garvel Park and Loch Gilphead, with perhaps Lochaber. The presence of *Rissoa cancellata* and *R. striatula* (the latter only known fossil elsewhere at Selsey), so far removed from their present locality, is remarkable. The "head" over the Portland Beach and the Crystalline Stalagmite above the Cave Bear breccia of Kent's Hole correspond to this open-air earlier deposit.

Hessle Gravels, etc.—As the first portion of the Interglacial series culminated with the deepest submergence of the North and North-west, so the second part commences with its re-emergence. It is understood that depression is more pertinent to accumulation than

[1] Mr. Mackintosh, I think, is not very favourable to Molluscan evidence. I am afraid he is hardly a fair judge, as he divides this species into two genera.

is elevation; hence there is little to wonder at that marine life in this stage should be so much less active in appearance than in the preceding period; and nearly all deposits, whatever height they may occupy, belonging to this stage, have been deposited in shallow waters. Present elevation goes for nothing: for example, the living zone of *Saxicava Norvegica* is from 30 to 90 fathoms, and of *Thracia convexa* 4 to 70 fathoms, yet they occur between tide marks on the same level on exactly opposite sides of Scotland, namely, at Bute and the Frith of Forth.

A few of the Scotch shell clays belong to this stage, but the non-Arctic shell-beds are chiefly of post "minor glacial" or Neolithic age, certainly those in which *Pecten Islandicus*, *Tellina calcarea*, and *Astarte borealis*, species still living within easy reach of our coasts (as in Faroe and Norway), are conspicuously absent.

The Marine Gravels of March and Hunstanton below the Fen Peats, and those of Kelsey Hill in the north, and Chislet in the south, belong to this era, the association of *Corbicula* and fluviatile species with marine forms in the two latter being very noticeable, indicating beyond any doubt that marine conditions again prevailed in the North Sea. The March gravels may be of a slightly earlier age, equivalent to the Barnwell freshwater gravels; they cannot be far away.

This epoch is the so-called palæolithic or rough stone implement age of Man, and the prevalence of rough-shapen tools from Peterborough southwards, and their absence together with that of the accompanying Mammalia in Wales, Scotland, and Ireland, affords a fair inference that these places were under water at the time. As a general rule, the more advanced manufactured weapons are in the newer deposits; but, just as Dr. Schliemann found at Troy a Bronze people, succeeded by a Neolithic one, so inferior tools occasionally are *supra* the better-class weapons. Stratigraphically they must be received with caution.

In order of time the fauna of the Bedford Ouse and Thet valleys, the Somerset caves, the Upper Thames gravels, and the Kirkdale and Settle[1] caves, in which Reindeer are few or absent, seem to precede the Fisherton gravels with Marmot, and the Windsor, Rugby, Windy Knoll, and Gower Caves in which they are more plentiful, the Cave earth of Kent's Hole and Cresswell Crags with bone harpoons evidently being the most advanced of all. Professor Prestwich's suggestion that the Hippopotamus was fitted for a more northern climate than it now inhabits seems to be irrefutable, since it is found associated with remains of species widely separated from it now in space and climate. Such separations among old associates are common enough among the Mollusca. Taking Butley again for an instance, of shells which in life were associated, and are now found side by side fossil, *Gastrana laminosa* is Natalese, *Tellina obliqua* Japanese, *Fusus altum* North Cape, *Admete viridula* Greenlandic.

[1] The supposition that the lower cave earth here is Preglacial will not bear investigation.

Much yet remains to be learnt about the migration of the Mammalia. The Musk Sheep and Glutton in the Forest Bed again reappeared, when a colder period was setting in again, in company with the Northern Lynx and Arctic Fox. But Mr. Howorth has pointed out that rain and damp are the main agents in the delimitations of range of the Reindeer and Musk Sheep, the fresh skulls of the latter occurring at lower latitudes than it now occupies. Prof. Boyd Dawkins has so thoroughly entered into this branch of Palæontology, that I prefer leaving such questions to him.

The Mundesley river bed may probably belong here. The *Hydrobia marginata* (*Belgrandia nana*, Sandb.) and *Elephas antiquus* correlates it to this stage, and if so the presence of the little Chelonian *Emys lutaria* may place the fluviatile deposit at Wretham Mere, Norfolk, with it. I take it that many of the caves just referred to were inhabited, without cessation, during the following minor glaciation, from Yorkshire southwards.

I have lately obtained from the pebble beds overlying the London Clay close to Minster, Sheppey, a flint implement. The two pebble or gravel beds were probably continuous originally.

The Implement gravels of Herne Bay and the South of Hampshire, and the thick yellow clay with large southern erratic rock masses overlying the Selsey mud bed, must be placed here. This clay boulder bed is too often confused with the angular marine gravel above. This gravel I may say helps to form the mass of shingle on the beach, *but* the shingle is *not* composed only of this fall or talus, but is augmented by a large accession of rolled pebbles of all ages, travelling from the westward, a fact often lost sight of.

To this latter half of the Interglacial period I consider the Somme and Seine gravels belong, not to the earlier Thames (Crayford) portion. The tuffs of Cannstadt and of Moret in the Seine Valley will probably give the Flora of the time.

The Minor Glaciation.—Such period will include the Hessle Boulder-clay of Yorkshire, the Upper Boulder-clay of the N. West and Ireland, and probably some of the fossiliferous beds of Scotland, like Paisley and Kilchattan, not possessing so glacial a character as the earlier Fife and Bute beds.

In Lancashire and Westmoreland alternations are not uncommon, peat containing Mosses, Beetles, etc., not being very rare, the marine fauna in the clays, as in those of the low-lying Caithness lands, mostly being fragmentary and derivative. In the south its influence is chiefly felt in the "trail" Löess, Brick-earth, and Contorted Gravel in the Thames Valley Beds and Tolland's Bay; and to this age I am disposed to refer the raised beds on the Sheppey and Pegwell Bay Cliffs, and the long stretch of marine detritus and gravels extending from Brighton to Portsmouth, at all heights, from nearly sea-level to upwards of 200 feet.

The final relics of this era are the Moraines, Eskers, and Kames, chiefly occurring in Ireland and the North, the Lancashire Shirdley Hill Sands and the Nar Valley. The numerous raised marine beds in Devonshire and Cornwall may be referred to here, together with

the Selsey superficial Brick-earth and the Brighton "Elephant" bed. The often-quoted deposit at Copford in Essex, and another containing a similar fauna, with flint flakes, at Stroud, Gloucestershire, 650 feet elevation, belong to this stage, some of the species being living known only in Yorkshire and far-distant places. Since the paper on the Copford beds was written by the late Mr. John Brown, the beds, although visited, I cannot find to have been practically worked by any one except myself, Mr. Dalton's memoir being mainly a recapitulation of Mr. Brown, *plus* sundry errors.

Will Mr. Dalton kindly say *where* Mr. S. V. Wood states that "three of the Helices from the Shell Marl no longer live in England," *i.e. H. ruderata*, *H. incarnata*, and *H. fruticum*: of the many thousands of Copford shells I have had in my hands, I have never seen one of the latter, and Mr. Wood's figure, as already mentioned, is that of a Stutton specimen. Mr. Wood further remarks that the *H. incarnata* requires confirmation, and he does not say in what bed the *H. ruderata* was found, simply giving Copford. My experience of the Marl is that very few shells, except freshwater species, are to be found in it, and Mr. Brown particularly observes that it is only where the marl passes into sandy clay at the sides, that they abound, and in the peat. Dr. Gwyn Jeffreys speaks of the *H. fruticum* as at Copford; the reference, he told me afterwards, was under a misapprehension of a remark of mine, that I had found the shell in England elsewhere than at Stutton. Sir C. Lyell, "Student's Manual," uses the same words as Mr. Dalton, but the account of Copford given by Sir Charles is inaccurate.

I have been a little more prolix than perhaps necessary, because *H. fruticum* belongs to a group of shells pertinent to an age long antecedent to the Copford peats, and the deposit is a typical one, often-quoted but so seldom correctly, that it is quite as well that an error should be set right if possible. Curiously enough, Mr. H. B. Woodward (Geol. England and Wales, p. 333) makes the blue clay beneath the marl to be the source of the Molluscan fauna. From this clay I obtained teeth of Rhinoceros, and a nearly complete set of teeth of a small deer, of which the whole skeleton was found.

Submerged forest and peat beds of this age may be occasionally seen at Torbay, Anglesey, and beneath the Carse Clays of Falkirk, and the Lothians, and the Buttery Clay of the Fens. Such peats as yield Elephant remains may be safely placed here. There is no improbability in supposing that the Mammoth lived on throughout the minor glaciation, since we find his remains in the Reindeer period in Kent's Hole, the two periods being, if not as they may probably have been, coeval, yet certainly closely, together in time; and there is every reason to believe that the Megaceros lived in Ireland long after its extinction in England, and that the Reindeer in Scotland was a still later survival.

The Bovey Heathfield Clay with *Betula nana* and Northern willows is, I think, an inland bed of this period; but it is possible that, like the *Cratægus pyracanthus* and others obtained from Grays Thurrock by Mr. Prestwich and *Pinus sylvestris* by myself, the flora belongs to the period succeeding the major glaciation.

The next or Neolithic stage corresponds with the formation of the 25 feet Raised Beaches of Scotland, comprising much of the ground bordering the Clyde, especially about Glasgow, in which *Tellina calcarea*, *Leda pernula* and other boreal shells appear for the last time in Britain. Some of the beds in this district may be newer still, as in various parts of the town of Glasgow many canoes have been exhumed, from the large canoe dug out by fire and stone, a beautiful weapon being found in one of them, to another in which a cork plug formed part of the equipments, and a well-made clinker-built boat with metallic (iron) fastenings.

The Carse Clays of East Scotland, and the Buttery Clays, or Fen Silts of Lincolnshire and Cambridgeshire; the Megaceros Peat and Bogs of Ireland, the Fen Peats with polished implements; and most of the submerged forest or tree patches skirting the coast, many west country, Scotch and Irish, caves, as Hoyle, Perth, Chwaren, Cefn, and a portion of the Settle Cave, Yorkshire, Oban and Kirkcudbright all fall in this period, but so gradually pass up into the more recent stage that an actual line of demarcation can seldom be drawn.

In these notes I have said but little about Ireland, having entered fully into the subject in a prior communication; it will suffice to say here that every observation made then is fully applicable now, and varies nothing from the lines worked upon above.

The latest deposits comprise the low level beaches in which the fauna is still existing, of which Belfast and Largo Bays, and Portrush furnish good examples, and the Scrobicularia clays and marine beaches in marshy places, as the Burtle beds of Somerset, from whence the sea has been comparatively speaking only recently excluded, the Alluvial flats of Lancashire, and the whole series of intercalated silts, clays, and peats of Somerset and Cornwall, the silts of tidal rivers, the now forming sandbanks and shingles of the coast-lines, the blown sands of Antrim with flint flakes, and of Galway and Cornwall, containing Helices of types (*H. nemoralis* in particular) of a size and structure now unknown, the Megaceros peat bogs and underlying marls of Ireland, and the forest and surface peats of Walthamstow, Newbury, Hull, Lincolnshire and Cambridgeshire, the Caves and Midden deposits of Richmond in Yorkshire, Scotland, and Ireland, and of Settle and Heathery Burn, the subaerial shell beds of the Isle of Wight and elsewhere, and the tufaceous marls formed by incrusting springs in Limestone districts.

All of these are due to such agencies as have been in ceaseless operation since the Bronze dolichocephalic man came into Britain. In Ireland there is every reason to suppose, and probably in the North of Scotland also, that stone implements were in use to a much later period than in England.

It would greatly facilitate the study of the later beds if authors would, instead of quoting in their lists "bones of birds or fish, elytra of insects," endeavour to ascertain what they are. Many species are lost to science for want of such determinations. A list of peat insects, and another of the plants absolutely found in (I do not mean a list of those living which make it) the peat are a great desideratum.

In the foregoing notes I have endeavoured to classify the principal deposits which throw any light upon the succession of the later deposits of our country, and by piecing the fauna and flora together to show that, beyond the vast cessation of life during the great or major glaciation, the succession of organic forms is one without violent alterations, or necessitating alternate cold and hot periods. There can be little reason to fear that ultimately a sequence of these varied deposits and their contents will be established. The fuller the lists are made, the sooner such a to-be-wished-for conclusion will be arrived at.

REVIEWS.

I.—Abhandlungen zur Geologischen Specialkarte von Elsass-Lothringen.

Ein Beitrag zur Kenntniss der Elsässer Tertiärs. Von Dr. A. Andreæ. Mit 12 lithographirten Tafeln, 2 Kartenskizzen, und 10 Zincographien. Band II. Heft. III. 1884.

Der Diluvialsand von Hangenbieten im Unter-Elsass, seine Geologischen und Palæontologischen Verhältnisse und vergleich seiner Fauna mit der recenten Fauna des Elsass. Von Dr. A. Andreæ. Mit 2 photographischen Tafeln, einem Profil und fünf Zincographien. Band IV. Heft. II. 1884.

Memoirs for the Special Geological Map of Alsace-Lorraine. A Contribution to the Knowledge of the Tertiary Strata of Alsace. By Dr. A. Andreæ. pp. 351, 12 4to. plates, 2 maps, and 10 zincographs.

The Geological and Palæontological Relations of the Diluvial Sand of Hangenbieten in Lower Alsace, and a Comparison of its Fauna with the present one of Alsace. By Dr. A. Andreæ. pp. 90, 2 photographed plates, 1 profile, and 5 zincographs.

In the first of these memoirs a detailed description is given of the Tertiary strata of Alsace. The lowest beds, which belong to the Middle Eocene, are freshwater limstones distinguished by the characteristic *Planorbis pseudammonius* and containing teeth of *Lophiodon* and other mammals. Above these are sandstones with plant-remains, and then thick beds of dolomitic limestones with *Melania* and other freshwater genera, referred to the Upper Eocene. Beds of Oligocene age are very extensively developed in Alsace, and, on account of their containing petroleum and bitumen, are economically important. Borings have been made in them to a depth in some places of 300 mètres without penetrating through them. The lowest Oligocene strata consist of beds of gypsum, apparently of brackish-water origin; these are succeeded by petroleum-bearing marls and sandstones, and then marine deposits of sand, marls, septarian-clays with numerous foraminifera, and fish-bearing shales, which belong to the Middle Oligocene. The Upper Oligocene deposits are marine or strongly brackish marls, sandstones and conglomerates.

The fauna and flora of these Tertiary deposits are very carefully described and most admirably illustrated in the accompanying atlas of plates; the figures have been drawn by the author's own hand. Numerous new species of freshwater mollusca and of foraminifera are introduced.

The second memoir consists of a detailed description of a section of diluvial or Post-Tertiary sands and marls exposed in the Rhine valley at Hangenbieten, a short distance from Strassburg. The total thickness of the deposits is about 15 mètres. The uppermost stratum is a typical non-stratified Loess, containing land-shells exclusively, which the author regards as Post-Glacial. Beneath this is a Loess of nearly the same petrographical character as the bed above, but containing freshwater as well as land-shells. Next below is a reddish sand—known as renovated Vogesen sand—which contains 17 species of land and 13 of freshwater shells, and in places remains of Mammoth and Reindeer. The author places this, and the Loess above it, as probably of Glacial age. Under the Vogesen sand are concretionary marls, in which the freshwater molluscs are more numerous than the land forms, and these are succeeded below by fluviatile sands in which 79 species of molluscs (48 land and 31 freshwater) have been discovered. Four of these are entirely extinct species, and many others have altogether disappeared from the district. A still lower bed of sand with but few fossils in it forms the base of the section. These lower beds are regarded as of Interglacial age.

The author furnishes a table in which a comparison is made of the fauna of the Hangenbieten section with that now existing in Elsace and the district of the Upper Rhine, and with that of Mosbach near Biebrich and of Mauer near Heidelberg. Descriptions are given of some new forms, and all the species are shown with remarkable clearness in the appended photographic plates. G. J. H.

II.—Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen des Jura. Von Dr. Rüst, in Freiburg I./B. Palæontographica, Band xxxi. Mit Tafel i.—xx. (Cassel, 1885.)

Contributions to the Knowledge of Fossil Radiolaria from Rocks of the Jura. By Dr. Ruest, of Freiburg. Palæontographica, vol. xxxi. pp. 51, with 20 plates.

With the exception of a few species of Radiolarians from the Upper Chalk of North Germany described by Zittel, and 18 species from the Lower Lias of the Tyrol, which Dunikowski has named and figured,[1] scarcely anything has hitherto been known of fossil Radiolaria from strata older the Tertiary, and these minute siliceous organisms have been regarded as forming but an insignificant part of the fauna of the older rocks. The present memoir, in which 234 different species of Radiolaria belonging to 76 genera, are described from Cretaceous and Jurassic strata, furnishes good evidence

[1] Dr. G. C. Wallich has lately called attention to the occurrence of Radiolarians in the cavities of flints from the Upper Chalk of Surrey, but they have not yet been described. Ann. and Mag. Nat. Hist. 5th ser. vol. xii. p. 52, 1883.

that they flourished as abundantly and in as great variety of form in the seas of these periods, as in those of Tertiary and recent times.

From the Middle and Upper Chalk Dr. Rüst discovered but few Radiolarians, they were however abundant in Neocomian limestone at Urschlau in Upper Bavaria. The so-called *Aptychus*-Schiefer from Urschlau and several other places in the Tyrol were found to be very rich in well-preserved specimens. They also occur in the Jasper and Chert from rocks of "Tithon" age in the Upper Alpine Jura at Allgäu, near Murnau, and other places in the Tyrol. In the red jasper the Radiolarians are so abundant that their shells are in close contact in the rock, whilst in the chert on the other hand they are comparatively rare. In this latter material the Radiolarians are replaced by sponge-remains and foraminifera, and many dark beds of chert are stated to consist of bedded masses of scattered sponge-skeletons (in the same manner as turf consists of remains of *Sphagnum*), with a few scattered Radiolaria between. The red jasper however, may be compared to a Radiolarian mud, like that brought up from the greatest ocean depths by the Challenger expedition.

Fragments of this jasper, containing the same species of Radiolarians, are found in gravels all over West Switzerland, and they are most abundant in the Nagelfluh of the Rigi and the conglomerate of Uetliberg.

In Hungary also, in chert and jasper of the age of the Tithon, the Malm, and the Middle Dogger, Radiolarians were discovered.

The author obtained his richest harvest of Radiolarians from Coprolites occurring mingled in beds of iron ore, which are largely worked at Ilsede, near Peine, in Hanover.[1] The ore-deposits rest on Gault-clay and are overlaid by Cretaceous marls, but neither in the rocks above nor in those below were Radiolarians discovered. The coprolites in these beds are round or cylindrical in form, and vary from the size of a lentil to that of a goose's egg, they are largely employed for making superphosphate. The age of these coprolites was determined by the occurrence with them of two species of *Ammonites*; one, *A. torulosus*, Zieten, characteristic of the Lower Dogger, and the other, *A. caprinus*, Schlot., of the Upper Lias. The author investigated coprolites from the Lias of Lyme Regis and Gloucester, which corresponded closely in character with those from Ilsede, but only in those from Gloucester were some few Radiolarian remains discovered.

Further, in red limestones of Middle Lias age, and in Chert of the Lower Lias in Hungary, Radiolarians were also present.

The author calls attention to the fact that whilst in Jurassic and Tertiary strata a Radiolarian-fauna is so largely developed, in the intervening Cretaceous beds hardly a dozen species have been found, and it seems also to be a general rule, that where sponge-remains and foraminifera are abundant, Radiolarians are of rare occurrence, and *vice versa*.

[1] The geological horizon of these coprolitic iron-ore beds appears to be the same as that of the Cambridge Greensand; and it is worthy of notice that Radiolarians have been discovered by Prof. Sollas in the Coprolites of this latter deposit, but they have not yet been described. See Quart. Journ. Geol. Soc. vol. xxix. 1873, p. 78.

With the exception of two, apparently extinct, genera (*Podocapsa* and *Salpingocapsa*), all the Jurassic Radiolarians can be included in the genera set forth in Hæckel's Prodromus Systematis Radiolarium. As a rule these older forms are more regular, simpler, and somewhat larger than the recent, and they have less adornment and armature.

The species described are clearly shown in 18 of the accompanying plates; most of the figures are drawn to the scale of 300 diameters: on plate xix. are figures of plant-spores and other doubtful minute objects met with in connection with the Radiolarians, and on plate xx. some of the spicules of sponges are figured. These belong to three, if not four, of the principal divisions of siliceous sponges, and include some very peculiar forms. One of these resembles the so-called plumose (Tannen-baum) flesh-spicule of certain recent Hexactinellids, and is the first hexactinellid flesh-spicule which has been discovered in a fossil state. It would have been more satisfactory to know the scale on which the spicules have been drawn.

One need hardly state that this memoir is a very important addition to our knowledge of the microfauna of the Jurassic strata, and is strong testimony of the patient industry and zeal of the author in discovering these minute organisms from such various sources. We are promised future notices of Radiolarians from Triassic and Permian strata, which will be looked for with much interest.

G. J. H.

III.—Geology, Chemical, Physical, and Stratigraphical. By Joseph Prestwich, M.A., F.R.S., F.G.S. In Two Volumes. Vol. I. Chemical and Physical. Royal 8vo. pp. xxiv. and 478, with three Chromo-lithographic folding Maps, three folding Coloured Sheets of Sections, and 218 Woodcuts. (Oxford: At the Clarendon Press, 1886.)

THIS is an epoch marked by the production of geological text-books. Year after year, a steady flow of manuals issues from the press, and one prophet after another arises, each with some special claim upon the attention of teachers and students.

Among the vast array of really good books the treatise just issued by the Clarendon Press deserves our special notice, coming as it does from the pen of Prof. Prestwich, one of the oldest living exponents of the science, whose papers upon the Tertiary Geology of the South-East of England, of France and Belgium, and upon the Geology of Coalbrookdale, etc., may be found scattered *broadcast* through the Transactions, Proceedings, and Quarterly Journal of the Geological Society, while others upon cognate subjects adorn the Philosophical Transactions of the Royal Society and the pages of the Geological Magazine.

The volume before us is devoted to Chemical and Physical Geology, and will shortly be followed by a Stratigraphical and Palæontological companion. Three very pleasing features in the present book are the excellency of the paper, the typography, and the illustrations—matters, alas! too often neglected, but having a most vital importance in the success or failure of a work. Three chromo-lithographic

folding maps, three sets of folding coloured sections, and no fewer than 218 woodcuts (many of which are specially prepared for the present work) adorn and make bright its pages, and render good service in the elucidation of the author's views.

Professor Prestwich, in his preliminary remarks, observes that among geologists two schools have arisen, "one of which adopts uniformity of action in all time,—while the other considers that the physical forces were more active and energetic in past geological periods than at present."

"On the Continent and in America the latter view prevails, but in this country the theory of uniformity has been more generally held and taught. To this theory I have always seen very grave objections; and I felt I should be supplying a want by placing before the student the views of a school which, until of late, has hardly had its exponent in English text-books." It must be borne in mind, however, that "the doctrine of non-uniformity must not be confounded with a blind reliance on catastrophes; nor does it, as might be supposed from the tone of some of its opponents, involve any questions respecting uniformity of law, but only those respecting uniformity of action."

"I myself have long been led to conclude that the phenomena of geology, so far from showing uniformity of action in all time, present an unceasing series of changes dependent upon the circumstances of the time; and that, while the laws of chemistry and physics are unchangeable and as permanent as the material Universe itself, the exhibition of the consequences of those laws in their operation on the earth has been, as new conditions and new combinations successively arose in the course of its long geological history, one of constant variation in degree and intensity of action."

Prof. Prestwich very properly points out that, for the student, the first object "should be to study the laws to which the materials and masses he has to deal with are subject, and then to consider what may have been their action under varying conditions in past time." With this object the author has divided his work into four parts: "The first, treating of the composition of minerals and rocks forming the crust of the earth; the second, the mode of action of geological agencies under existing and under past conditions: while the third and fourth will treat of the succession of the groups of sedimentary strata and of the life thereof, and of some of the theoretical questions connected with the physical conditions prevailing during former periods of the earth's history." The four earlier chapters up to p. 61 comprise a consideration of the constituents of the Earth's crust, which are enumerated and described, and all the numberless forms of rocks resulting from the varying combination of their constituent minerals are discussed and exemplified.

The mode of action of geological agencies should have commenced at p. 62; but Chapter V. is occupied with an account of the "Order, Place, and Range of past Life." This we venture to think might have been held over and formed a part of Vol. II., in which the Life-history of the Earth will be discussed.

We live in an age of change, and in no department have greater changes arisen lately than in that of Biology. The author has brought together in this chapter a series of tables of classification of each group of the animal kingdom; but as these tables are necessarily by various authors, and of very varying dates of publication, from 1868 to 1883, *some at least* need emendation.

Thus in the classification of the MAMMALIA (p. 79) the Seals, (PINNIPEDIA) have been placed with the Cetacea, whereas they are now universally placed with the CARNIVORA; and the Sloths, Ant-eaters, and Armadillos (EDENTATA), have been placed between the CARNIVORA and RODENTIA, whereas they are now placed next the MARSUPIALIA.

The PROBOSCIDEA, PACHYDERMATA, SOLIPEDIA, and RUMINANTIA are not so arranged by later zoological writers, but they form one great order, the UNGULATA (or hoofed quadrupeds) divided into various sub-orders, as

Sub-order 1. HYRACOIDEA (Hyrax);
„ 2. PROBOSCIDEA (Elephants);
„ 3. AMBLYPODA (Dinoceras, etc.);
„ 4. PERISSODACTYLA (Tapirs, Rhinoceroses, Horses);
„ 5. ARTIODACTYLA (Pigs, Deer, Oxen, and Sheep).

Happily these and other needful modifications can be made in Volume II., which deals with the Life-history of the Earth, and is not yet published.

On p. 69 the MYRIOPODA have accidentally got between the DECAPODA and the CIRRIPEDIA; and on p. 68 *Entomostraca* and *Malacostraca* seem of equal classificatory value with INSECTA, the word CRUSTACEA, which should be the leading one, being sub-ordinated. The ARACHNIDA and MYRIOPODA should not be bracketed together, they are really *widely separated* groups. Neither should the MARSIPOBRANCHII and the PHARYNGOBRANCHII be bracketed together (p. 76). The first embraces the "Hag-fish" (*Myxine*) and "Lamprey" (*Petromyzon*); the second a single form the "Lancelet" (*Amphioxus*), so anomalous as to be by some naturalists relegated to a separate class!

It is, therefore, misleading to the student to bracket these two together with the remark (after "no fossil forms known") "? *Conodonts*"; for if the curious little microscopic bodies called "Conodonts" met with by Pander in Russia and by Hinde in the Cambro-Silurian and Devonian rocks of North America, are fish-teeth, which is very doubtful,[1] they must have belonged to the "Hag-fish" (*Myxine*), and could have nothing to do with *Amphioxus*, which is destitute of teeth or any other hard organs whatever.

But to pass on to the question [Chapter VI. (p. 82)] how "Sedimentary strata are formed by river and sea erosion." Commencing in the truly philosophical 'Lyellian' and 'Darwinian' style to argue from the known to the unknown, we find the author teaching his students "to study the effects of the agencies at present

[1] See Quart. Journ. Geol. Soc. vol. xxxv. 1879, pp. 351–368, plates xv.–xvii. Compare these with the odontophore of certain mollusca, *Strombus*, *Cassis*, *Triton*, etc.

acting on the surface of the globe, in so far as they are of a nature to furnish evidence which may assist in the interpretation of the mode of formation of the sedimentary strata, of the disturbances to which these strata have been subjected, and of the succession of life of which they contain the remains."

Then we have *Rain* treated as a geological agent; the formation of *Deltas*, their age; *River Denudation;* the formation of *Valleys; Drainage-Influences;* the *Cañons of the Colorado*,—illustrated by a page-cut of Marble-cañon and a glimpse at the Dolores cañon.

From this we pass to the consideration of *Marine Action,—the origin of the coast shingle in the English Channel*—illustrated by the famous case of the Chesil Bank—and the cause of the *wear of coasts*, illustrated by the gradual destruction of Lundy Island, an 'outlier' of the old North Devon Coast, the Chalk Cliffs of Brighton, Dover, etc.

In Chapter VII. the subject is continued, and we are invited to consider waste (by chemical solution) in the soluble matter carried down to the sea and into lakes by Rivers; its character and quantity; and the resultant formation of Calcareous strata.

The Organic origin of Limestones is next touched upon, and the presence of soluble silica in Cretaceous and Jurassic strata is adduced as evidence that a very different state of things existed then, to any which obtains in the present seas. May not the soluble silica referred to have been very largely derived from the *subsequent* decomposition of the vast numbers of siliceous sponges which are known to have existed in the seas of the Secondary period? and may not these chemical changes have taken place *long after* the Calcareous muds forming the sediments of these Mesozoic waters had been accumulated and to a great extent solidified?

The author refers to the various *modern Calcareous beds* now forming, such as the shell-limestones accumulating along many coasts like that of Guadaloupe, the Canaries and the Island of Ascension. He next glances at *Deposits in Lakes*, of which the shell-marls always form a most interesting series, often rich in organic remains.

From these the author passes on to consider those strata which owe their present state to subsequent chemical reaction, such as Magnesian Limestone, Gypsum and Rock-salt.

Space does not permit us to dwell longer on this interesting work. The seventeen chapters that follow are not merely a bare compilation from the works of other observers, but Prof. Prestwich is able to bring much of his own original labours in the past to bear upon the subjects under consideration, and so to exalt the work into a far higher position than that of an ordinary text-book.

We hope to come back to its consideration at a future day. A most valuable feature of the book is its excellent Index of 27 pages, of three columns to a page, which renders the contents easily accessible to all, and gives the book a very high place as a work of ready reference.

IV.—Memoirs of the Geological Survey.

1.—The Geology of Holderness, and the Adjoining Parts of Yorkshire and Lincolnshire. By Clement Reid, F.G.S. 8vo. pp. 177. (London, 1885.) Price 4*s*.

THIS Memoir is devoted to an account of the Glacial and Post-Glacial deposits of the Holderness district, that are included in the area of Sheets 85, 86, and 94 of the Geological Survey Map. The district was surveyed in part by Mr. J. R. Dakyns and in part by Mr. A. C. G. Cameron, as well as by Mr. Reid, who however has a personal knowledge of the entire region.

The Drift-deposits of Holderness occupy an old bay bounded by Chalk hills, a bay whose form is due to the relative hardness of the lower and upper beds of Chalk, the former standing out in the bold headland of Flamborough. The Drift-deposits have been banked up against the old line of Chalk cliffs, in places to a depth of 100 feet, so that while geologically speaking the ancient Bay of Holderness has been preserved, physically speaking it has been obliterated or smothered up.

The oldest Boulder-clay, known as the Basement-clay, is interesting from the occurrence in it of transported masses of sand and clay full of mollusca. These fossiliferous layers have been described under the name of Bridlington Crag; but the view that they are included in the Glacial Drift, advocated by Mr. S. V. Wood, has (with a different explanation) been confirmed by Mr. G. W. Lamplugh and Mr. Reid. It was indeed previously announced in the Geol. Mag. (Vol. I. 1864), by the late Dr. S. P. Woodward, that the Bridlington deposit can no longer be considered the equivalent of the Norwich Crag, being of an Arctic character, a conclusion which, as Mr. Reid remarks, "subsequent discoveries have only tended to confirm and strengthen." A revised list of organic remains from the Bridlington Crag is now published, and this includes, besides Mollusca, Plants, Foraminifera, Cirripedia, Entomostraca, and Vertebrata. The Vertebrata are probably derived from Crag, Eocene, or older deposits. Remains of Echinodermata and Polyzoa have been found, but these as yet are undetermined. Mr. Reid observes that while the Basement-clay is the lowest bed exposed in the Holderness cliffs, the Chalk is generally about 60 feet beneath the sea-level—hence older Glacial or even newer Pliocene beds may be concealed in places.

Above the Basement-clay, other layers of Boulder-clay, known as the Lower and Upper Purple Clays and the Hessle Clay, are locally to be distinguished. Mr. Reid makes some important observations on the weathering of Boulder-clay, whereby chalky Boulder-clay passes into reddish-brown stony loam.

Associated with the Boulder-clays are marine Inter-Glacial and other gravels and laminated clays. The Inter-Glacial beds have yielded mammalian bones, and a marine fauna indicating a climate that seems to have been little if at all colder than that of the same region at present. A full list is given of the organic remains found at Kelsey Hill, and other places, and a column showing the forms

found at March in Cambridgeshire is added. A description of the Post-Glacial deposits and their organic remains, contains the observation that *Felis spelæa* and perhaps *Elephas primigenius* are true Post-Glacial species. The Lion has been found at Hornsea, associated with the Irish Elk, Horse, and Red-Deer, apparently in the ancient deposits of the Mere.

A chapter is devoted to the changes now in progress. The serious loss of land along the coast-line within historic times is well known, and this is clearly illustrated by diagrams or reproductions of charts dating from 1684. Since this period the average rate of advance of the sea has in places been about $2\frac{1}{4}$ yards a year. In other places land has been gained.

A concluding chapter gives an account of the Economic Geology—soils, brickmaking, etc., with some mention of the Humber Tunnel. The Water-supply is also discussed, and details of a number of Well-sections and Borings are given. An appendix contains a list of works on Holderness.

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2. The Geology of Bridlington Bay. By J. R. Dakyns and C. Fox-Strangways. 8vo. pp. 18. (London, 1885.) Price 1*s*.

THIS is a brief explanation of Quarter-sheet 94 N.E. of the Geological Survey Map. It includes an account of the Chalk, Glacial and Post-Glacial Beds. Mr. Reid contributes the List of Fossils from the Bridlington Crag.

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3. The Geology of the South-West Part of Lincolnshire, with Parts of Leicestershire and Nottinghamshire. By A. J. Jukes-Browne, B.A., F.G.S. (Parts by W. H. Dalton, F.G.S.) 8vo. pp. 180. (London, 1885.) Price 4*s*.

THIS is a description of the rocks embraced in the area of Sheet 70 of the Geological Survey Map. The area was chiefly surveyed by the late Mr. W. H. Holloway, other portions being mapped by Messrs. W. H. Penning, W. H. Dalton, and A. J. Jukes-Browne. The rocks include the Upper Keuper Marls, the Rhætic Beds, the Lias, the Oolites from the Northampton Sand to the Kimmeridge Clay, and various Glacial and Post-Glacial deposits.

Detailed descriptions of the strata are given, and the palæontological divisions, with lists of fossils, are duly noted. The junction of the Lower with the Middle Lias is taken at the top of the clays with *Ammonites capricornus*: so that a number of forms regarded as Middle Lias in Dorsetshire are now placed in the Lower Lias. This higher line was adopted by Prof. Judd in the Rutlandshire district, and hence it was desirable to continue it northwards. *Ammonites communis* is noted from the Middle Lias, so that our notions of the value of Ammonites as indices of zones are liable to be shaken. It is remarked that the zones of *Ammonites Humphriesianus* and *A. Parkinsoni* are altogether absent from Lincolnshire, unless the former is represented by the upper portion of the Lincolnshire Oolite.

The Glacial deposits include representatives of the Chalky Boulder-

clay, Purple and Hessle Clays, with associated gravels. The large transported masses of Lincolnshire Limestone and Marlstone, to which attention was first directed by Prof. Morris, are described; and Mr. Jukes-Browne regards them as due, together with the Boulder-clay itself, to the agency of coast-ice.

Among the mineral resources of the district, the Lincolnshire Limestone is noteworthy, being largely quarried at Ancaster. Of the iron-ores, that derived from the Marlstone Rock-bed is most important, and it has been lately described by Mr. E. Wilson ("Midland Naturalist," vol. viii. 1885). The gypsum in the New Red Marls at Newark is also extensively worked.

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4. The Geology of Eskdale, Rosedale, etc. By C. Fox-Strangways, F.G.S., C. Reid, F.G.S., and G. Barrow, F.G.S. 8vo. pp. 65. (London, 1885.) Price 1*s.* 6*d.*

THIS is an Explanation of Quarter-sheet 96 N.E. of the Geological Survey Map. It contains an account of the Lias, the Oolites from the Dogger to the Middle Calcareous Grit, and of the Glacial and Post-Glacial beds.

The Upper beds of the Middle Lias, which constitute the Ironstone series, are described in detail. They furnish the well-known Cleveland Ironstone. The Dogger, which occurs at the base of the Oolites, is a variable bed changing from limestone to sandstone, and in places yielding the valuable iron-ore of Rosedale.

In the Lower Estuarine Series, above the Dogger, comes the Ellerbeck Bed, yielding marine fossils, which was described by Mr. Barrow in the Geological Magazine (Decade II. Vol. IV. p. 552). Higher up there is a bed of coal which has been worked. The Grey Limestone Series, and the Upper Estuarine Series, the Cornbrash, Kellaways Rock, Oxford Clay, and Corallian Rocks, present many features of interest, and their palæontological contents are duly noted. The Whinstone or Cleveland Dyke is an intrusive dyke of augite-andesite.

The absence of Drift over most of the country now described is remarkable. Boulder-clay extends to a height of about 800 feet in the valleys to the north of the table-land, but is not met with in the interior, nor has any trace been found there of local glaciation. Hence it is concluded that the uplands formed an insular space round which the ice-sheets swept, while these high grounds were not glaciated.

5.—The Geology of the Coasts adjoining Rhyl, Abergele and Colwyn. By Aubrey Strahan, M.A., F.G.S. (with Notes by R. H. Tiddeman, M.A., F.G.S.) 8vo. pp. 73. (London.) Price 1*s.* 6*d.*

THE area here described is included in Quarter-sheet 79 N.W. of the Geological Survey Map, and was originally surveyed by Messrs. W. T. Aveline, W. W. Smyth, and A. C. Ramsay. The ground having been re-surveyed on the scale of six inches to a mile, by Messrs. Tiddeman and Strahan, the map has been revised, and this Explanation published.

The rocks include Wenlock Shales, Carboniferous Rocks, Bunter Sandstone, Glacial Drifts and Post-Glacial Beds. Between the Basement-beds of the Carboniferous rocks (red conglomerates, etc.) there exists "one of the greatest unconformities to be met with in the British Isles," the Silurian strata having been cleaved, contorted, and denuded before the overlying rocks were laid down. In the pebbles of these Carboniferous conglomerates many Ludlow fossils have been found.

The principal formation described is the Carboniferous Limestone, from which many fossils have been obtained. The Millstone Grit is interesting, from the remarkable development of chert met with. Mr. Strahan remarks that unlike the bands and nodules of chert in the Carboniferous Limestone, this chert is probably a siliceous sediment of extreme fineness; for not only is it well stratified, and evenly laminated, but, by a gradual lithological change, it passes horizontally into a fine-grained quartzose sandstone, with bands of chert, and finally into a quartz grit with quartz pebbles, in which chert bands are quite subordinate. The Lower Coal-Measures and Trias are briefly described. The whole of the low ground and the flatter parts of the high ground are overspread by Drift-deposits consisting of Boulder-clay and Gravels. The Post-Glacial Beds comprise Calcareous Tufa, Peat and Alluvium, and Blown Sand. In a Chapter on Economic Geology accounts are given of Lead and Zinc Ores, Hæmatite, etc. An Appendix contains a list of works on the Geology, etc., of Denbighshire and Flintshire, by Messrs. Whitaker and Strahan.

V.—The Geological Record.

THE "Geological Record" was founded in 1874, with the object of publishing a yearly register of all publications relating to Geology, Mineralogy, and Palæontology. The volumes for the years 1874 to 1878 have appeared with brief abstracts: that for 1879 is in the press. These have been prepared under the editorship of Mr. William Whitaker, B.A., F.G.S., who has spared no pains, amid many disappointments and delays, to render the volumes as complete as possible.

The British Association gives a grant in aid, sufficing for some assistance, the correction of proofs, etc. The greater part of the work, however, is done by geologists who give their help gratuitously. There are no funds available for the purchase or exchange of publications. Hence the Editor is to a very large extent dependent on the exertions of voluntary assistants. No doubt the delays have tended to damp the ardour of many who have laboured on behalf of the Geological Record.

Mr. Whitaker has now retired from the position of Editor, and Mr. William Topley, F.G.S., Assoc. Inst. Civil Eng., has bravely undertaken to carry on the work. In order to bring the "Geological Record" up to date, he has decided to issue one volume for the five years 1880–1884 with titles only, and to resume the abstracts for the year 1885.

From a circular just issued we learn that the present Editor would gladly welcome further assistance, and would be especially thankful if authors would forward to him brief notices of papers, etc., appearing in the publications of provincial societies, which are often not easily obtained in London. Authors, secretaries of societies, and editors of geological publications would also greatly assist the work by forwarding copies of their publications to the Editor of the "Geological Record," 28, Jermyn Street, London, S.W.

VI.—Proceedings of the Chester Society of Natural Science. No. 3. 8vo. pp. 134; 9 Plates. (Printed and Published by Giles Griffith, Chester, 1885.)

THE present volume includes fifteen papers upon various subjects read before the Society from 1878 to 1884. Of these papers eight are of geological and palæontological interest.

The first is by the President of the Society, Prof. T. McKenny Hughes, M.A., F.G.S., entitled "Notes on the Geology of the Vale of Clwyd." As to the merits of this paper it is sufficient to say that it is upon a subject which is peculiarly the author's own. It is illustrated by eight plates (23 figures), and is a most valuable contribution to the geology of the district. After a short introduction, the rocks found in the Vale of Clwyd are briefly described in order, beginning with the oldest or Bala series, and passing upwards to the recent Cave-deposits. Under each formation we have a list of its chief fossils and peculiarities of structure and comparisons with the same horizons in other districts, along with valuable local notes as to where the most interesting sections may be most easily observed. There is a valuable note "On the Weathering of Mountain Limestone," explaining in a very clear manner the formation of those caves with which we are all so familiar in limestone districts, and at the same time mentioning places where the effect of the weathering may most easily be observed. It is impossible to over-estimate the importance of such a paper as this to local geologists; for, rich as it is in facts and details, it is still richer in suggestions which need for their working out the time and patience of the local geologist; and we do not doubt that this paper by the President will originate much good work, which will appear in future volumes of the Proceedings.

The next paper is by Mr. Aubrey Strahan, M.A., F.G.S., on "The Denudations of North Wales." This is an admirable paper by one who for a long time was associated with the Society as Honorary Curator of the museum, when he was engaged in the Geological Survey of the district. In the present paper Mr. Strahan proposes to examine the evidence, afforded by examples in this district, of the fact that "while existing lands, being themselves chiefly formed of stratified marine material, occupy the sites of seas of former geological periods, on the other hand these seas overspread the ruins of still more ancient continents." This paper is one which all local geologists should read, and all the places mentioned will well repay a fresh visit in the new light thrown on them by Mr. Strahan's paper.

Then follows a paper by Professor Judd, F.R.S.—"A Problem

for Cheshire Geologists." The paper is an abstract of one read before the Society, Nov. 27th, 1878. Professor Judd shows that the strata of the various formations were originally much more widely distributed over the British Islands than they are at the present day, and that the breaks in their continuity must have been caused by subsequent denudation. Not only is this true in the case of the older Carboniferous rocks. It is probable that before the deposition of the Tertiary rocks, the greater part of the British Islands was "buried under the thick strata of the Liassic and Oolitic age, and that a great winding sheet of Chalk enveloped nearly the whole of the country." The greater part of the Secondary strata has now been removed by denudation, and much interest naturally attaches to these isolated patches or "outliers." One such patch is in the district lying between Audlem and Wem, and the problem for Cheshire geologists, writes the Professor, is—(1) To determine the exact extent and limits of the outlier. (2) The relations to the surrounding strata. (3) The nature, thickness, and fossil contents of the outlier. We hope Cheshire geologists are now on their way at least to the solution of this geological problem.

We now come to a very short note on "Traces of an Interglacial Land-surface at Crewe," by that veteran geologist Mr. D. Mackintosh, F.G.S. These traces the author supposes he has found in an exceedingly fine and more or less flexible kind of leaf-clay which he discovered at the Crewe Railway Station.

The next paper is one by Mr. W. Shone, F.G.S., on "The Silting-up of the River Dee: its Causes." As an introduction to his paper, Mr. Shone first gives us some account of the river both in historic and in prehistoric times, with some interesting quotations from early writers. Then follow a number of details—the result of much patient observation—as to the rate of flow of the tide up the river, and its rate of outflow back again to the sea. Mr. Shone attributes the silting-up of the river to several causes combined, the chief of which are—the tapping of the water at Llangollen for the canal; the building of the causeway, and the reclaiming of the land on Sealand. We cannot help thinking that, after all, the real cause of the silting-up of the Dee is the extremely small amount of fresh water which comes down from Bala Lake. We know that in dry seasons, with the exception of a small quantity of water which passes over the mill, no water at all finds its way over the Causeway, and of course there would be just the same flow so far as volume is concerned, whether the Causeway were there or not. But the upper part of the river instead of being practically a long lake would be a shallow muddy river, were the Causeway removed.

Three papers follow by Mr. A. O. Walker, the first two on entomology and the third on a meteorological subject. The first, on "Climatic Causes affecting the Distribution of the Lepidoptera in Great Britain." The second is "A List of the Macro-lepidoptera of the District." The third by Mr. Walker is on the "Climate of the Cheshire District in Relation to Fruit-growing."

Dr. Stolterfoth follows with an account of his work at "Surface Dredging in the Dee." This paper is especially interesting to microscopists, as it deals entirely with diatoms and the lower forms of animal life, and shows how very abundant are the lower forms of life in the estuary of the Dee. Then four papers by Mr. G. W. Shrubsole. The first a note on the Polyzoon, "*Glauconome disticha*, from the Bala beds of Glyn Ceiriog." In this paper Mr. Shrubsole describes a new genus of Polyzoon, which for some time has been regarded as identical with *Glauconome disticha* from the Dudley beds. The new name proposed is *Pinnatopora Sedgwickii*. There is a list of land and freshwater shells compiled by Mr. Shrubsole "from local collections sent in from time to time at the annual conversaziones." It consists of 93 species and 19 varieties, and is followed by a few interesting remarks. A paper "On the Occurrence of *Calcisphæra* (Williamson) in the Mountain Limestone of the Eglwyseg rocks, near Llangollen," by Mr. Shrubsole, follows next. In this paper Mr. Shrubsole has brought together in a clear and concise manner all that is known about these curious fossil Rhizopods, about which there has been so much dispute as to whether we should classify them with the Foraminifera in virtue of the calcareous material of which their remains are composed, or with the Radiolaria in virtue of their minute structure. There is also a brief note by Mr. Shrubsole on the occurrence of *Venus mercenaria*. Then follows a paper, by Mr. Ruddy—"A List of Caradoc or Bala Fossils, found in the Neighbourhood of Bala, Corwen, and Glyn Ceiriog"—one of the most valuable in this number of the Proceedings, giving evidence of years of patient work, and which no one who wishes to work at the Bala beds can possibly afford to be without. The last paper is a botanical one by Mr. J. D. Siddall, on "The American Water-weed, *Anacharis alsinastrum*, Bab.," illustrated by a carefully drawn plate.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Dec. 16, 1885.—W. Carruthers, Esq., Vice-President, in the Chair.—The following communications were read:—

1. "Old Sea-beaches at Teignmouth, Devon." By G. Wareing Ormerod, Esq., M.A., F.G.S.

The author stated that while old records show that no important changes have taken place in the level of the Teignmouth district during the historical period, the excavations made in recent drainage-operations in the present year showed the existence of at least two series of beaches. The oldest sea-beach, which is a few feet above the present sea-level, was partly washed away and then covered up by later deposits exhibiting evidence, in a number of delicate bivalve shells in an unbroken condition, of having been deposited in a calm sea.

2. "On the Gabbros, Dolerites, and Basalts of Tertiary Age in Scotland and Ireland." By Prof. John W. Judd, F.R.S., Sec.G.S.

In previous papers published in 1874 and 1876, it has been demonstrated by the author that there exist in Scotland and in Hungary igneous rock-masses presenting the most perfectly crystalline characters and belonging to the Tertiary period. It was further shown that such highly crystalline, plutonic rocks are seen passing insensibly into volcanic rocks of the same chemical composition—gabbros into basalts, diorites and quartz-diorites into andesites, and quartz-andesites and granites into rhyolites—the lavas in turn graduating into the perfectly vitreous types known as tachylytes and obsidians.

The present paper deals with the basic rocks of Western Scotland and Northern Ireland, which are shown to exhibit the most marked analogies with rocks of the same age in the Faroe Isles and Iceland; these facts lend strong support to the doctrine of the existence of petrographical provinces. The Tertiary age of the Scotch and Irish rocks is placed beyond dispute by the fact that they overlie unconformably the youngest members of the Cretaceous system, and are interbedded with stratified deposits of Lower Tertiary age.

With regard to the nomenclature of these rocks, the identification of the more crystalline forms with the gabbros, which was made by Zirkel and Von Lasaulx, is supported; while the use of the term "dolerite" as a convenient one for the connecting links between the gabbros and basalts is advocated.

Of the original minerals contained in these rocks, plagioclase felspar (ranging in composition from anorthite to labradorite), augite, olivine, and magnetite, are regarded as the essential ones; while enstatite, biotite, chromite, picotite, and titanoferrite are among the most frequently occurring accessories. It is shown, however, that these original minerals may belong to different periods of consolidation. The Secondary minerals are very numerous, including quartz, epidote, zoisite, hornblende, serpentine, and zeolites, with many other crystallized and uncrystallized substances. There are remarkable variations in the relative *proportions* of the original minerals in different examples of the rock; and by the complete disappearance of one or other of the constituents, the gabbros are sometimes found passing into picrites, eucrites, or troctolites.

In their microscopic structure these rocks present many interesting features. From the highly crystalline gabbros there are two lines of descent to the vitreous tachylytes: one through the *ophitic* dolerites and basalts, and the magma-basalts with skeleton-crystals; and the other through the *granulitic* dolerites and basalts, and the magma-basalts with granular microliths. The former are shown to result from the cooling down of molten masses which were in a state of perfect internal equilibrium; while the latter were formed when the mass was subject to movement and internal strain.

It is shown that in the most deeply seated of these rocks (gabbros) the whole of the iron-oxides combine with silica; but, as we approach the surface, the quantity of these oxides separating as magnetite increases, until it attains its maximum in the tachylytes. In all the varieties the order of separation of the different minerals is shown

not to depend solely on chemical causes, but to be influenced by the conditions under which the rocks have cooled down.

Although these rocks are not highly altered ones, yet they afford admirable opportunities of studying the incipient changes in their constituent minerals. The nature of these changes is discussed, and they are referred to the following causes:—(1) the corrosive action of the surrounding magma on the crystals; (2) the changes produced by solvents acting under pressure in the deep-seated masses (these have been already described under the name of "schillerization"); (3) the action of heated water and gas escaping at the surface; (4) the action of atmospheric agents on the rocks when exposed by denudation; and (5) the changes induced by pressure during the great movements to which rock-masses are subjected.

II.—Jan. 13, 1886.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.

The President said, It may not be known to all present this evening that during the past week we have lost a well-known member of forty years' standing. Prof. John Morris died last Thursday, and to-day some of us have stood by his grave in Kensal Green Cemetery. The Society has lost its most learned member, and many of us have been deprived of a very dear friend.

1. "On some Fish-remains from the Tertiary Strata of New Zealand." By James W. Davis, Esq., F.G.S.

A number of fossil fish-remains from Tertiary beds in New Zealand have been forwarded to the author by Captain F. W. Hutton, and were described in the present paper. The forms of which descriptions were given are two new species of *Lamna*, *Carcharodon angustidens*, Agassiz, and a new *Carcharodon*, one new species of *Notidanus*, one of *Myliobatis*, and one referred to *Sparnodus*. All the above are founded on teeth. A vertebra of *Lamna* and a fish-spine were also described, and the collection contained a specimen regarded by the author as a fragment of a Reptilian tooth.

2. "On a recent Section through Walton Common, exposing the London Clay, Bagshot Beds, and Plateau-gravel." By W. H. Hudleston, Esq., F.R.S., F.G.S.

During the past autumn the widening of the line between Walton and Weybridge stations has afforded a very interesting section in the above beds, showing their relations to each other with considerable clearness. Walton Station is 68 feet above O.D., and immediately to the westward the section described in the paper commences, the surface of the country gradually rising to a height of about 120 feet in the plateau which separates the drainage of the Mole from the drainage of the Wey. This plateau is connected on the south by a

slope with the higher and far narrower plateau of St. George's Hill, having an elevation of 245 feet.

For convenience of reference the portion of the section more particularly described, and which has a length of 1070 yards, is divided into four blocks :—

Block A extends from Walton Station to where the unaltered London Clay is seen—313 yards.

Block B extends from this to the point where the Bagshot beds are first seen *in situ*—345 yards.

Block C extends from the above to the point where the Bagshots are first cut through to the level of the line, and the hollow filled up with Plateau-gravel—165 yards.

Block D exhibits the relations of the Bagshots to the Plateau-gravel, where the latter is most fully developed—247 yards.

Details of Block A.—This portion of the section rises from zero to 12 or 14 feet; the first bed which becomes visible is the "Top Sand," and on advancing further westward portions of a peculiar mixture of gravel and lumps of brown clay form the sides and floor of the cutting. This is evidently a disturbed series, and has peculiar relations with a mass of yellow sand, mainly false-bedded, which is 70 yards long, and from 12 to 14 feet high at the west end. The London Clay *in situ* rises very suddenly beyond this. Reasons were given for supposing this sand to be a superficial deposit against a steeply eroded surface of London Clay.

Details of Block B.—The London Clay of this block has yielded no fossils, nor are any Septaria visible. The bedding is difficult to distinguish, but recent weathering has made it more plain. This seems to establish a very slight dip towards the west. The surface of the London Clay is undulating, and it is overlain by from 6 to 7 feet of Plateau-gravel.

Details of Block C.—In this block, where the cutting has a depth of about 24 feet throughout, occurs the junction of the Lower Bagshots with the London Clay, and this is apparently an unconformable one. Both the lithology and the stratigraphy favour this view. Nothing in the nature of a lithological passage exists. The lowest bed of the Bagshots here is remarkably clear sand full of false-bedding, and is succeeded by an argillaceous series, also somewhat sandy. It was suggested that this latter might be the equivalent of the "Ramsdell Clay."

Details of Block D.—Here the Plateau-gravel attains its maximum thickness, since the Bagshots are cut through to the level of the line in three places—depth of cutting from 24 to 27 feet,—thus affording a fine opportunity for the study of this peculiar deposit. Three horizons were roughly made out, or, rather, three varieties occurring one above the other. Beyond the limits of the section there is more distinct evidence of at least two groups in these Plateau-gravels. No materials from the northern drifts are found.

Other sections in the superficial beds were noticed, and more especially one about the 180-feet line on the north slope of St. George's Hill, where the contortions are of considerable interest.

PROF. JOHN MORRIS, M.A. CANTAB., F.G.S., ETC.

BORN FEBRUARY 19TH, 1810; DIED JANUARY 7TH, 1886.

[For more than twenty years one of the Editors of this MAGAZINE.]

The new year has gathered into its earliest garner another ripened human intellect, whose influence and usefulness in the Geological world for nearly 50 years have done much to promote in others a love for our science to which that life was devoted.

Professor John Morris was born in the very dawn of accurate Geological thought in this country.

Eight years before his birth, in the spring of 1802, Playfair had published his celebrated "Illustrations of the Huttonian Theory." In 1807, a handful of scientific men met together and founded the Geological Society of London; and from 1799 to 1815 William Smith (better known as "the Father of English Geology") was plodding over England, with quiet unobtrusive labour, preparing, unaided, his work, entitled "Strata Identified by Means of their Organized Fossils," and his great "Map of the Strata of England and Wales."

In June, 1812, James Sowerby commenced to publish (in about bi-monthly parts of 5 plates each) his "Mineral Conchology of Great Britain."

Such was the condition of the literature of our science in England early in this century. There were no text-books for young geologists in those days, and the science of Geology was no easy path to pursue; yet John Morris had already taken up the study of rocks, minerals, and fossils, and commenced to collect materials for his "Catalogue of British Fossils," before the first edition of Lyell's "Elements" had been printed, and as early as the first appearance of his "Principles of Geology," a little book of one volume 8vo., which saw the light in January, 1830, whilst Morris, then twenty years of age, was engaged in business in Kensington as a Pharmaceutical Chemist.

The modest precursor to Morris's Catalogue was printed at Norwich, and designated "A Synoptical Table of British Organic Remains, in which all the edited British Fossils are systematically and stratigraphically arranged in accordance with the views of the geologists of the present day, and a reference given to their localities, strata, and engraved figures, by Samuel Woodward." This little book of fifty pages, which appeared in 1830, gave all that was known at that date concerning our British Fossils.

Morris published the first Edition of his Catalogue in 1845, but he had issued preliminary notes, section by section, in the "Magazine of Natural History" from 1839 to that date.

The second edition appeared in 1854; but though constantly urged by his friends to do so, and incited by the awards of the Geological Society, he never achieved a third edition.